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The Engineering Development of the Empire.

IN our present issue, which we may designate as the first Empire Number, the space usually assigned to special original contributions has been devoted to an interesting series of articles dealing with the engineering development of several British colonies, written in most cases by experts nominated by their respective Governments. It was at first intended that the series should include South Africa, India and the Crown Colonies, but it was found impossible to do justice to all within the limits of one number. The contributions included in the present issue have been limited to Canada, Queensland, New South Wales, Western Australia and New Zealand, leaving India and the remaining colonies to be dealt with in a future special issue which it is proposed to publish at the time of meeting of the colonial conference next year.

The contents of our present issue point very clearly to the fact, that the old-fashioned idea of colonies as retail establishments for the distribution of goods produced in the manufactory, or supplied by the wholesale firms of Great Britain, is rapidly becoming obsolete. Farming and mining no longer constitute the only pursuits worthy of notice in the outlying realms of the empire, and even these occupations are conducted on a scale demanding the most modern machinery, apparatus, and appliances. Railways, roads and bridges are being constructed, extended and improved; harbour, river, canal, and irrigation schemes are being undertaken; and municipal and

sanitary engineering projects are everywhere in evidence. All these developments find occupation for professional men and skilled labour, and demand also the products of industrial engineers to an ever-increasing extent.

It is not the case, however, that the manufacturers of Great Britain benefit in corresponding measure, for apart from competition by foreign countries, the tendency is for every State to become more and more self-reliant, to establish local industries and to protect them by tariff against competition—and in a modified way even against competition on the part of the Mother Country. In process of time, we may reasonably expect that countries having at hand iron and other metals used in engineering work will make a point of using them to the utmost advantage, and will cease to look upon Great Britain as a central workshop. Industrial nations throughout the world have long ago seen the unwisdom, from their own point of view, of admitting us to their markets to the detriment of home industries, and, unless we are greatly mistaken, self-governing British States will take a similar view when their local industries require support. When that day comes, the home demand of the British Isles will probably occupy the attention of our manufacturers far more than it does at present, and if the disastrous policy of so-called "free trade" then survives, the position will not be a pleasant one.

Under existing fiscal arrangements, the enormous flow of foreign-made machinery and engineering products into this country compels manufacturers to look towards British colonies for help, and after these have been developed into great industrial countries such help will only be forthcoming to a limited extent. Hence, in years to come, Great Britain will be less a universal provider for the colonies than the head among a group of prosperous industrial countries, each more or less able to supply its own demand for manufactured articles. It may be thought that we are looking a long way ahead. That is in fact the case, but surely it is better to take steps now for conserving the national industries of Great Britain, in the manner adopted by every other country of the world, than to wait until the free import and decreased export of manufactured goods have brought a state approaching disaster to our shores.

LOCOMOTIVE BUILDING IN AUSTRALIA AND NEW ZEALAND.—Most of the rolling-stock for Australasian railways has hitherto been purchased in Great Britain, but it does not seem likely that this state of things will continue indefinitely. Even in states where engineering enterprise is by no means conspicuous, the railway authorities have spent large sums in the erection and equipment of locomotive shops, and have already commenced the building of locomotives. The new workshops recently completed near Perth, Western Australia, at a cost of nearly £500,000, occupy a site of 93 acres, of which nearly 9 acres are under cover, but so far operations have been limited to the repair of locomotives, carriages, and wagons. In Queensland, several tank engines have been built at the works of the State railways near Brisbane, which cover about 14 acres and were built at a cost of nearly £400,000. The railway shops of New Zealand have steadily increased in size and number, and to-day five of the locomotive works belonging to the State are provided with machinery of the most modern types for the construction of rolling stock. The railway department have placed in service three goods engines of their own make on one section of the system, and have decided to build a number of four-cylinder compound locomotives of greater power than any hitherto used for passenger and goods traffic, and, further, to build heavy goods engines for certain steep inclines on the North Island Main Trunk line.

Still more striking evidence of the movement in the direction of home-manufacture is furnished by the history of locomotive building in New South Wales, of which a *resumé* is given by Mr. J. W. Roberts, of Sydney, in the article which we publish this month. Since 1870, locomotives have been built in the State workshops and by various local firms, and the Government now propose to confine themselves entirely to locomotives constructed in the State. As our readers are aware, they have already signed a contract for the construction of sixty locomotives, at the total cost of about £322,000, by the Clyde Engineering Company of New South Wales. If, as there is every reason to believe, this venture should prove successful, the importation of locomotives will become a thing of the past, and the example of New South Wales will doubtless be followed elsewhere in the Commonwealth. Although they may not be gratifying to locomotive builders at home, the developments we have mentioned are satisfactory as a promise that the constructive genius of the British race will be worthily perpetuated in the Southern hemisphere.

BRITISH ENGINEERS AND CANADA.—When we consider the remarkable developments that have characterised all branches of engineering work in Canada during the last ten years, it is truly surprising to find that industrial firms in the home country have, almost without exception, allowed themselves to be outdistanced by their competitors in the United States. To obtain a fairly adequate notion of the vast field that exists in Canada for commercial enterprise on the part of British firms, it is only necessary to glance at the various directions taken by engineering development in that country. Chief among them is that represented by the continuous extension of the railway system, the main object of which is to establish more complete communication between the great grain-growing regions of the west, and the commercial and industrial centres of the east. The magnitude of this movement is illustrated by the far-reaching projects of the Grand Trunk Pacific Railway for the construction of an entirely new Transcontinental line, some 3,600 miles in length, at a cost of £25,000,000, and by the Canadian Northern Railway extensions, which it is hoped will ultimately lead to the establishment of a third line of communication between the Atlantic and Pacific Oceans. The Canadian Pacific Railway also are busy in the construction of new branches, and the replacement of early bridge and other structures by works of permanent character. In consequence of these and kindred projects, fully a million tons of steel rails will be required in the Dominion during the next five years for new railway lines, to say nothing of steel for bridge and general structural work. Notwithstanding the efforts made by the Dominion Government to encourage the production of steel by the payment of bounties on steel rails and other rolled sections, the output of Canadian steel work is insufficient for the average needs of the country, and quite inadequate for exceptional demands, such as those we have mentioned. Therefore, large quantities of material continue to be imported, chiefly from the United States. Considering the fact that freight from Great Britain is somewhat less than the railway rates from the United States, it does seem strange that our steel manufacturers should so quietly surrender an important outlet for their products.

One thing we are sorry to notice is that for structural work American rolled sections are generally preferred to those complying with the British standard. In the article by Professor Durley, published elsewhere in this issue, it is stated that American sections are found to be more economical. This is a somewhat disconcerting suggestion, to which the attention of the Engineering Standards Committee should certainly be directed. Without exhaustive comparison of American with British sections, it would be impossible to form any reliable opinion on the subject, but after comparing the leading sizes of bars rolled by one of the leading firms in the United States with those specified in the British standard, we find no grounds for a sweeping statement of the kind. In some cases American sections have a slight advantage, and in others British sections are more economical. Moreover, we think it probable that the latitude as to thickness allowed by the British standard should enable our manufacturers to compete on perfectly level terms with their rivals in the United States. The point here raised is an important one, for, whether it be correct or not, the impression that American structural sections are the more economical is distinctly calculated to divert orders from Great Britain to the United States.

In the direction of locomotive practice there is a growing tendency for Canadian railways to build their own rolling stock, while for the supply of lines not equipped with locomotive shops, large works have been established by various firms in different parts of the country. British makers willing to participate in this department of work will certainly have to take into account the fact that locomotives for Canada must be in general accordance with American practice, and it should not be forgotten that the use of superheated steam is rapidly becoming a distinctive feature of Canadian locomotives, largely owing to the substantial advantages demonstrated by its adoption on the Canadian Pacific Railway.

So far as mechanical and electrical engineering are concerned, comparatively little has been done by British firms to secure their due share of the business arising from the great activity that has been displayed of late in the equipment of industrial works and the execution of contracts for municipalities all over the country. Quick to seize upon every opportunity for trade, engineering firms in the United States have established Canadian works for the production and supply of their specialties without the payment of import duties, and for the purpose of counterbalancing the 33⅓ per cent. preference accorded to manufacturers in the home country. We cannot imagine why British firms show such reluctance to follow a similar policy, and to settle themselves

right in the thick of the great business now going on in Canada. Nor do we know why they are content to let their rivals in the United States carry off the bulk of the import trade of Canada in mechanical and electrical apparatus, in spite of a deterrent tariff and the heavy cost of railway as compared with ocean freight.

AUSTRALIAN IRON AND STEEL.—Until quite recently very little effort has been made by the various Australian States to follow the enterprising example set by Canada in the manufacture of iron and steel. Since 1896, when the output was only 600,000 tons, the production of Canadian blast furnaces has been increased to fully 400,000 tons, and there are now eighteen rolling mills in active operation, while five others are under construction or projected. In Australia, valuable iron ore deposits exist in almost every part, and in New South Wales alone it is estimated that no less than 53 million tons of magnetite, brown hematite, limonite, and bog iron ore are in sight, capable of yielding some 27 million tons of metallic iron. Coal of good quality is to be found close to all the important deposits, which are accessible to the State Railway system. The first practical step taken for the encouragement of the iron industry in New South Wales was the invitation of tenders by the Government for all the pig iron and rolled steel required during a period of seven years, the essential condition being that the whole of the material should be produced and manufactured in the State. Notwithstanding this encouragement, only one tender was received—that of the Eskdale Iron and Steel Rolling Mills. These works cover a site of some twenty acres, and are equipped with two four-ton Siemens-Martin open hearth furnaces, in addition to rolling mills for rails and structural sections. Instead of importing blooms and ingots as formerly, the works will now undertake the local production of pig iron for Government requirements and the manufacture of such steel sections as may be permitted by the capacity of the plant. The venture deserves to be closely watched in this country, for when once it is proved that iron can be produced and manufactured with commercial success in Australia we may be sure that every effort will be made to foster and protect the new industry.

THE COOLGARDIE WATER SUPPLY SYSTEM.—The undertaking recently brought into operation by the Public Works Department of Western Australia, for the supply of water to the Coolgardie Goldfields is one of the most valuable works hitherto projected in Australia. The scheme involved the construction of a concrete dam, 755 feet long by 100 feet high, forming a reservoir seven miles long on the Helena River. Water is conveyed to the Goldfields through a 30-inch steel main, 352 miles long, and as the reservoir is 1,290 feet lower than the surface reservoir at Coolgardie the whole supply has to be pumped. For this purpose eight pumping stations have been established along the pipe line, and when delivering the maximum supply of five-and-a-half million gallons daily the total head of 2,500 feet is divided over the pumps. Considering the length of the pipe line and the fact that the whole of the water has to be pumped against so great a head the undertaking justly deserves to be ranked among the great engineering achievements of the present era.

ELECTRICITY IN CANADA AND AUSTRALIA.—Among the special articles there are many references showing the extensive application that is being made of electricity in the chief states of the Empire. With unrivalled facilities for the generation of energy at minimum cost, Canada naturally takes the premier position, and the chief hydro-electric plants constructed in the Dominion during the last ten years have an aggregate output not much below 600,000 horse power. So great is the demand for electrical apparatus of all kinds that although the present output of Canadian firms engaged in the industry is not far short of £1,000,000 per annum, it is necessary to import electrical machinery and appliances on a large scale, chiefly from the United States. Throughout Australia and New Zealand the use of electricity for power and light has become universal in mining work, tramway installations, engineering and other industrial establishments, and for various municipal purposes. Electric lighting is general in small towns, as well as in great cities, and is even being applied in some of the larger pastoral stations. One of the most significant illustrations of advanced practice is furnished by the proposed electrification of the Sydney Suburban Railway system. This project, which we understand will very shortly be commenced, is only one of many examples showing how closely Australians are following the most modern applications of electricity.

THE TRANS-AUSTRALIAN RAILWAY.—Considering the magnitude of

Australia and the advanced state of development attained by that great country, it is surprising that so little—using the word in a comparative sense—is known about it in Great Britain and Europe generally. The great engineering project for a railway from Kalgoorlie in Western Australia to Port Augusta in South Australia is one of the things scarcely heard of outside the Commonwealth, and yet it is fully worthy of comparison with kindred undertakings in Africa, America, and Asia, of which particulars have been published throughout the world. One great object of the scheme is to bring Western Australia into closer touch with the rest of the Continent, from which it is now separated by a long sea voyage or alternatively by an arduous journey on land. The route has already been surveyed, and as soon as the formal assent of South Australia has been received, the construction of the line will be commenced by the Federal Government. In addition to the utility of the railway to the mining, timber, and agricultural industries of Western Australia, the new communication will be of much value to the whole Commonwealth, for by it all the States of Australia will be linked up, and when one or two gaps have been filled, passengers will be able to perform an uninterrupted railway journey of nearly 5,000 miles, between Fremantle, in Western Australia, and Towersville, in Queensland.

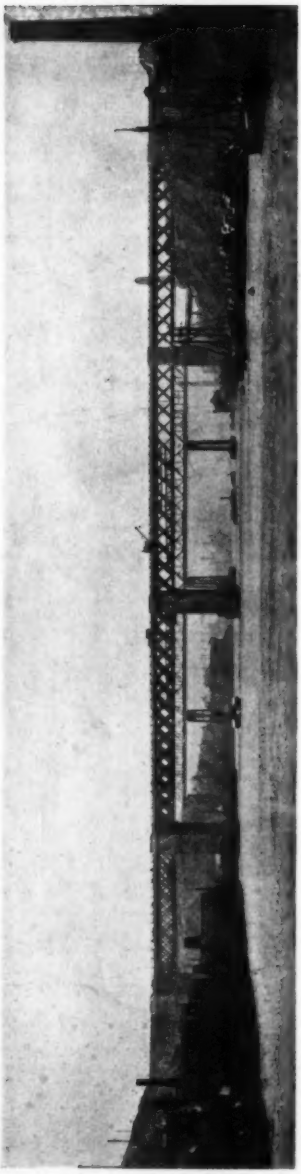
The Month.

The Charing Cross Disaster.—At last the report of Major Pringle to the Board of Trade has been published on the accident at Charing Cross in December last. So far as the main facts are concerned very little essential information is conveyed beyond that already given to the public by the evidence taken at the coroner's inquiry, although it certainly is the fact that all the facts, together with diagrams and other illustrations, are now presented in a convenient form for study and future reference. We pointed out in our Editorial note of February last, that "all the morals and warnings which have been drawn from the occurrence and published so freely in the daily press fall wide of the mark," an opinion which is generally confirmed by Major Pringle, who considers the weight of the temporary staging in use at the time of the accident to have been the immediate cause of failure, but as the total tension on the bar did not exceed 5·13 tons per sq. in. on the whole sectional area, the railway engineers are completely exonerated, and could have no reason for anticipating danger, especially as it has been proved that the flaw in the tie-rod could not possibly be detected by examination so long as the bar remained in the roof. The report also confirms the generally admitted fact that the failure was brought about by the breaking of the tie-bar in the main principal nearest to the wind screen, and the description of the fractured bar given in our article of January last.

The lessons drawn from the accident by Major Pringle are the following:—(1) That in old roofs of similar design, more especially where welded bars of any size have been used, there is danger to be guarded against of concealed flaws which may grow in size under continued tensional stress, although in itself that stress may not be exceptional; (2) that unless additional security be afforded by the duplication or strengthening of the main tensional members there is possible risk of failure; (3) that where such risk of failure exists, it is necessary to consider whether the walls supporting the roof are in themselves sufficiently strong to resist the thrust which such failure will bring on them, and if not to strengthen them.

No one can doubt the soundness of these conclusions, the most important being that which recommends the duplication of tie-bars made in days when welding was a necessary process in the manufacture of large wrought iron members of the kind. The advice that the supporting walls should be strengthened as an additional safeguard is also good, and if old roofs and their supports are treated in the manner suggested we shall be reasonably safe against any further accidents caused by unforeseen and invisible flaws. So far as strictly modern engineering practice is concerned, however, no general lesson is to be derived from the Charing Cross accident, and nothing to be inferred to the detriment of steel structures.

The New High-Level Bridge at Newcastle.—The new high-level bridge



NEWCASTLE HIGH-LEVEL BRIDGE. VIEW TAKEN 5TH JUNE, 1906, FROM PIERS OF THE OLD HIGH-LEVEL BRIDGE. THE REDHEUGH BRIDGE IS IN THE BACKGROUND.

Photo, F. C. Coleman, Darlington.

at Newcastle, which is now virtually complete, will provide many much-needed facilities for dealing with the heavy traffic through the Newcastle central station of the North-Eastern Railway system. Hitherto, the company have had to depend upon the old high-level bridge constructed in 1845, for the crossing of the river Tyne, but the rapidly increasing traffic—some 800 trains and engines now pass over it daily—for some time past rendered the structure inadequate for the requirements.

The position has been rendered no less easy by the fact that all trains from the south entering Newcastle station before resuming their journey north, and *vice versâ*, have had to be hauled out in a reversed direction. Structural alterations made at both ends of the station, the construction of a new railway, and the provision of the new bridge will now, however, permit of trains running through, thus saving much time and many complications.

The new structure has been erected between the old high-level bridge and the Redheugh bridge, and has occupied rather more than three and a half years in building.

It is a four-span structure of lattice girder construction with granite piers, and measures 1,150 ft. between abutments. The two centre spans are each 300 ft., and the two outer spans 191 ft. and 231 ft. respectively, the latter being on the Newcastle or northern side. From the underside of the girders to high water level the distance is 83 ft. The piers, which are built on caissons, are of grey granite, and are carried down to a depth of 69 ft. below high water level. They are 103 ft. 6 in. in extreme width at cutwater, the latter at each end being 17 ft. 6 in. The superstructure consists of five main double lattice girders, with top and bottom booms 3 ft. deep, braced together at top and bottom by transoms. The lower transoms are of lattice work, the upper of plate work, 16½ in. deep, the latter carrying the timberway on which the rails are laid. With the exception of those in the southern span, the main girders are spaced 11 ft. centre to centre, are each 4 ft. 6 in. in width and 27 ft. in depth, the breadth of steel work overall being 50 ft. In the southern span the girders are not laid parallel, as the rails at this point begin to spread out. Trough flooring is used in this section, to permit of which the three inside girders are reduced in depth to 24 ft. The girders for the centre spans are cambered 7½ in., the north span 6 in. The panels are 23 ft., and the lattice girder struts and ties composing them are 4 ft. 1½ in. wide. On the piers the top booms have been

bracketed out to within 6 in. of each other, and the free end of each girder rests in steel roller-bearings to provide for expansion. The parapets, which are of lattice work, are 5 ft. high. Of the four sets of rails which the bridge accommodates, two are to be used for passenger and two for goods traffic. Mr. C. A. Harrison, M.Inst.C.E., the chief engineer of the northern division of the North-Eastern Railway, is responsible for the design, the contractors being the Cleveland Bridge and Engineering Co., Ltd., Darlington.

The London County Council Electricity Generating Station at Greenwich.—The new electricity generating station at Greenwich, which was opened on May 26th last, has been constructed for the purpose of supplying energy for the South London Tramway system worked by the London County Council, and will eventually serve for any that may be so worked in the near future. That is, unless its removal is decided upon in consequence of its proximity to Greenwich observatory, the authorities of which institution are vigorously complaining that the vibration set up by the heavy reciprocating parts interferes with their instruments, and that the smoke and vapour from the shafts render exact observations over them impossible.

The site of the stations is on the bank of the river at Greenwich, about 250 yards eastwards of Greenwich Hospital. The building is in two parts, the first of which is now completed, and the second part is in progress. The complete structure will measure about 475 ft. by 195 ft. and 80 ft. in height.

The design of the complete station provides for eight steam generators and forty-eight boilers, but only half of the station is being built at the moment. The present portion contains machinery of the reciprocating engine type, and a total capacity of 14,000 k.w., but it is proposed in the second portion to use turbo-generators, with a total capacity of 20,000 k.w., or 34,000 k.w. in all for the complete station.

The coal is unloaded from the steamers by three electric cranes, with grabs, holding about 25 cwt. each. The grabs discharge into trucks on the pier, which, after passing over weighbridges, are discharged into a large steel bunker holding 2,000 tons. From this bunker the coal is conveyed by gravity bucket conveyors, to the bunkers immediately over the boilers. The object of using an outside bunker of this capacity was to enable a steamer to be unloaded in the shortest possible time without being dependent upon the comparatively slow rate of an ordinary conveyor.

On their return journey the buckets pass through a tunnel under the boiler house, and take the ashes from hoppers below the boilers, and carry them to a storage hopper under the pier, whence they are discharged into the barges.

The boiler house contains twenty-four water-tube boilers of the five drum Stirling Company's type. Each with an evaporative capacity of about 16,300 lb., of water per hour.

Each pair of boilers has its own economiser on the floor above, consisting of 320 tubes, arranged in thirty-two sections. The economisers have been made and erected by Messrs. E. Green & Sons, Manchester, and the scrapers are driven through worm gearing by small independent three-phase motors.

Above the economisers, and at the top part of the boiler house, are situated the coal bunkers.

In the basement are situated on the one side two feed pump rooms, each containing three horizontal ram pumps by Mr. John Cochrane, of Glasgow. Each pump is driven by a series wound "Bruce-Peebles" motor of 35 h.p., and the pumps will deliver 8,000 gallons of water per hour against a pressure of 225 lbs.

On the other side of the boiler basement are situated hot well tanks, from which the feed pumps take their supply. These are filled from the condensers, after the water has passed through "Harris-Anderson" purifiers.

The engine room contains four steam generating sets of 3,500 k.w. normal capacity each. The engines are by Messrs. John Musgrave & Sons, Ltd., of Bolton, and are of the vertical-horizontal type. Each engine consists of two complete half engines, one on each side of the generator, consisting of a vertical h.p. cylinder, 33½ in. diameter, and a horizontal l.p. cylinder 66 in. diameter. The stroke in each case is 4 ft., and the two connecting rods on the one side of the engines, work on to a common overhung crank pin.

The engine runs at 94 r.p.m., and work at 180 lbs. steam pressure. "Corliss" valves are used, and the exhaust steam from the h.p. cylinder passes through a receiver on its way to the l.p. cylinder, and is there reheated by live steam direct from the boilers.

The whole of the engines are entirely enclosed, and work with forced oil lubrication. By the placing of the h.p. cylinder in the vertical position the drainage becomes

perfectly natural, and there are no places in which water can lodge. An independent steam supply is given to each h.p. cylinder, and each l.p. cylinder has its own condenser in the basement.

The condensers are of the surface type, with separate motor driven airpumps. On its way to the condensers the exhaust steam passes through "Baker" oil separators, but before the condensed water passes to the hot well, it is treated in "Harris-Anderson" purifiers.

The generators are by the Electric Construction Company, Ltd., and are mounted directly on the engine shafts. They are all of the revolving field type, and three-phase current at 6,600 volts between phases, at twenty-five complete cycles per second. The normal output is 3,500 k.w. or 306 amperes per phase, and 4,375 k.w. on emergency overload. The stators are star wound, with the centre point earthed. The coils are former wound, and are laid in open slots. There are five slots per pole per phase.

The magnets are built up of laminated steel stampings, secured in dovetailed slots on the periphery of the fly wheel. The coils are wound one layer deep, of bare copper tape on edge, and are held down by laminated pole tips.

The excitation is at 125 volts, and each alternator has its own independent exciter by driven ropes from a pulley on the main shaft. A standby is provided by the steam auxiliary sets mentioned below.

In addition to the four main generators, there are two independent direct current steam sets, each of 150 k.w. capacity, which are used for lighting station, a standby for excitation, and other uses.

The switchgear throughout is of the oil-break, remote-control, electrically-operated type, and has been built by the British Westinghouse Electric and Manufacturing Company, Ltd., of Manchester.

The feeders leave the station in two groups by means of two separate tunnels. One tunnel carries the cables for supplying the north of London, via the Blackwall Tunnel, and the other the cables for the south of London.

Adjoining the switchboard recess is a sub-station, which contains three motor generators for supplying direct current to the local tramway lines and for station purposes. It is equipped with three motor generators by Messrs. Dick, Kerr & Co., Ltd. Each machine is of 500 k.w. capacity, runs at 300 r.p.m., and transforms the 6,600 volts three-phase current to direct current at 550 volts pressure. A battery of 280 "Tudor" accumulator cells is provided in the basement, close to the sub-station, for use in conjunction with the sub-station plan.

The Cunard Liner "Lusitania."

The launch of the 25-knot Cunard Liner *Lusitania* marks an epoch in the annals of marine engineering, and of the stupendous advance which the vessel represents in size, speed, and method of propulsion over hitherto existing practice much has already been written.

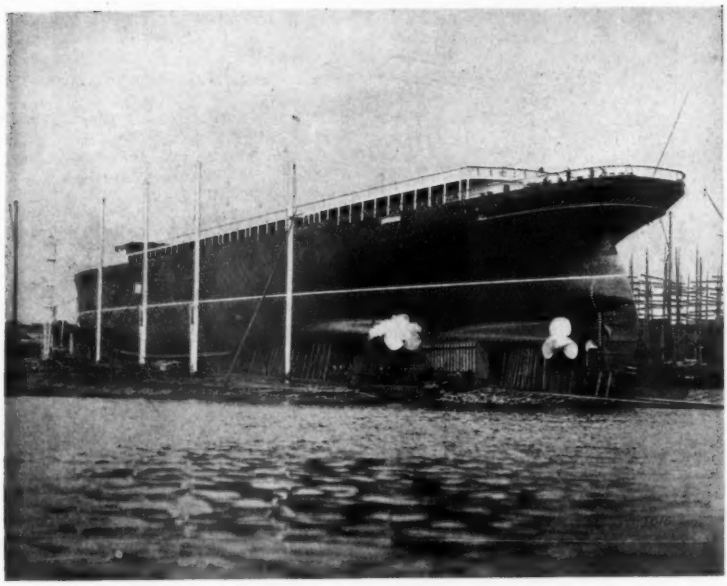
Not only from the engineering point of view has our interest been excited, but also from the fact that the vessel, as is her sister ship the *Mauritania*, now nearing completion in the yards of Messrs. Swan, Hunter, and Wigham Richardson, Ltd., Wallsend, is the outcome of the determination to maintain British supremacy for speed in the Atlantic, which was wrested from us by the German 23-knot liner *Kaiser Wilhelm II.*

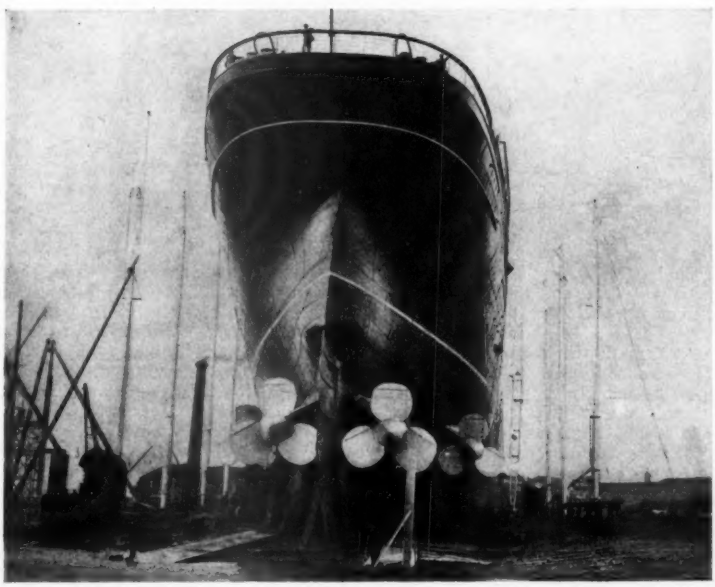
To secure this extra speed of two knots with a hull form which was determined upon after an exhaustive series of experiments, involves the generation of 70,000 i.h.-p. and its transmission through four shafts each driving an independent propeller. The two wing shafts are driven by two high-pressure turbines, the exhaust from which passes to two low-pressure turbines driving the inner propeller shafts.

Two reverse turbines for manipulating the vessel astern are also fitted on the inner shafts.

Steam is provided by twenty-five boilers of the cylindrical return tube type working at 200 lbs. pressure, twenty-three of which are double-ended, with four furnaces at each end, there being 192 furnaces in all, arranged to work on the "Howden" system of forced draught. The total grate area is about 4,000 ft., and the total heating surface is 160,000 sq. ft., so that there are practically 40 sq. ft. of such surface to every square foot of grate. The boilers are arranged in four groups, having the uptakes led into one funnel, of which there are four, oval in section, so as to minimise the effect of wind pressure. The fore and aft diameters of the funnels are 24 ft. and rise to a height of 120 ft. above the normal load water line.

The other principal features of the vessel as described in the official description are as follows:—Length overall, 790 ft.; breadth (moulded), 88 ft.; depth (moulded), 60 ft.; gross tonnage, 32,500 tons; displacement tonnage, 45,000; loaded draught, 37 ft. 6 in.; height of masts, 216 ft. The *Lusitania* is 160 ft. longer than the *Campania*, and

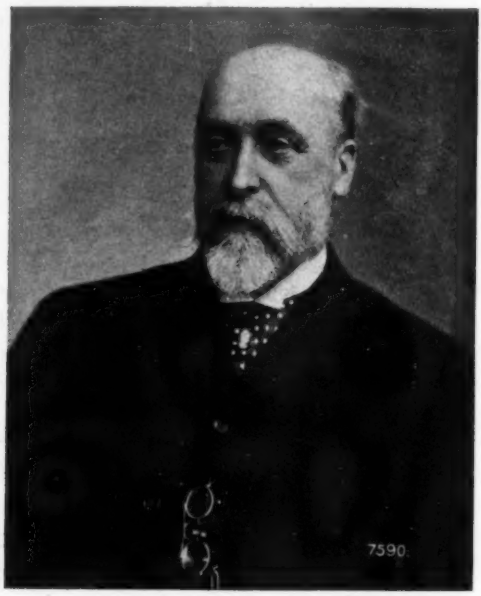




THE 25-KNOT CUNARD LINER "LUSITANIA.

78 ft. 6 in. longer than the fastest vessel on the Atlantic at present—the *Kaiser Wilhelm II.* The *Great Eastern*, it may be added, was 80 ft. shorter, 5 ft. less beam, and 3 ft. less depth. The *Lusitania* is relatively broader in the beam than her predecessors, and is exceptionally fine-ended. Her hull is constructed on the double-bottomed cellular system, the depth between the bottoms being 5 ft. The keel-plate consists of three thicknesses of plating, 5 ft. in width, making a total thickness of about 3¾ in. The double bottom—a complete system of transverse and longitudinal girders, rivetted entirely by hydraulic power—extends beyond the upper turn of the bilge, and the frames extending thence to the top of the moulded structure (about 55 ft.) are each about 15 cwt. The plating is for the most part in 40 ft. lengths, weighing from 4 to 5 tons, and, in some cases, has five rows of rivets. Altogether in binding the structure over 4,000,000 rivets have been used, aggregating in weight about 500 tons.

The vessel has in all nine decks, at least six of which form integral features of the ship as a structure. There are 175 water-tight compartments, and where there are doors through the bulkheads, at or below the water line for intercommunication, these are all of a special type, and can be closed automatically, simultaneously from the navigating bridge. The latter, it may be mentioned, is 110ft. above the keel. For the photographs we are indebted to the builders, Messrs. John Brown & Co., Clydebank, at whose yard the vessel, the launching weight of which was 16,000 tons, was sent off the stocks without a hitch.



THE LATE F. W. WEBB. (*See p. 72.*)
Photo by Elliot and Fry.]

Engineering Development in Canada from 1896 to 1906.

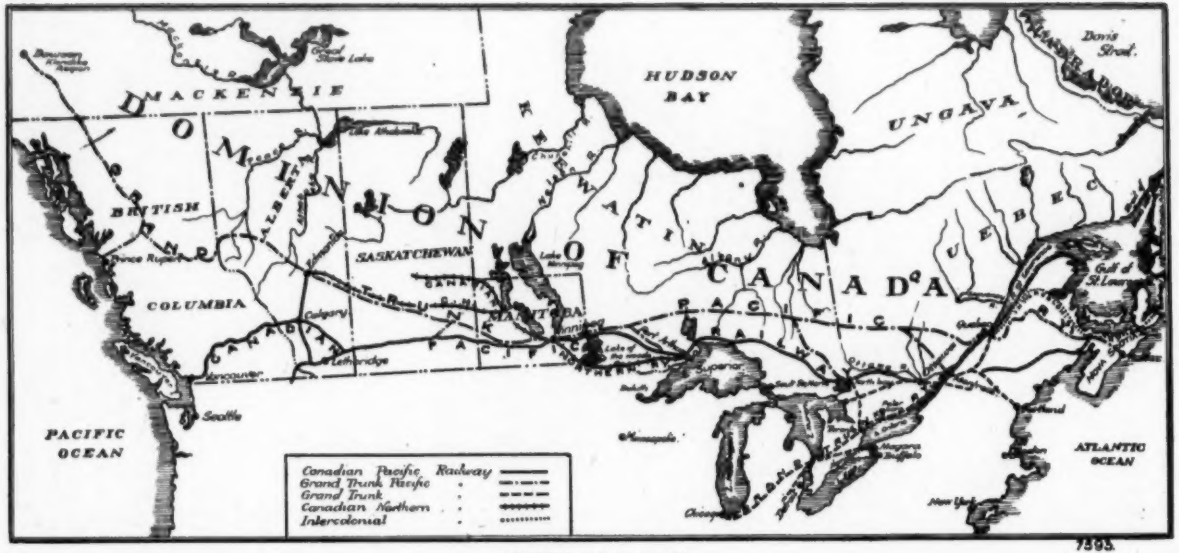
By Professor R. J. DURLEY, A.M.Inst.C.E., M.Am.Soc.M.E., M.Can.Soc.C.E.
(of the McGill University, Montreal).

DURING the last two or three years Canada and her wonderful resources, her vast areas of fertile land still open to settlement, and her people's firm belief in her great future, have been kept prominently before the British public. We read of the influx of experienced farmers from some of the more fully settled parts of the United States, statistics are published of the number of immigrants from the British Isles, and we hear of the stream of settlers from the Continent of Europe, all of whom are making homes for themselves in the great North West. But not many people realise that the eastern portion of the Dominion has made striking progress, although of another kind, during the past ten years; here an industrial and manufacturing, rather than an agricultural, development of equal importance has taken place. All this growth has naturally given rise to a great deal of engineering work; railways and canals have been constructed, water powers are being and have been developed, steel works and rolling mills have been built, machine shops and electrical works have been established, and these have been accompanied by a host of factories of other kinds. Activity in all branches of the engineer's work has been the rule.

Recent engineering development in Canada has taken place in two main directions, and has involved, first, the construction and continuous improvement of the great lines of communication by land and by water, together with the growth of their subsidiary industries, and next, the building up of the power plants, factories, mines and workshops required to supply the needs of the community at large.

As may be expected in a country where long journeys are so readily undertaken and where produce has to be transported over great distances, railways, rivers and canals play a great part in Canadian affairs, and these systems are highly developed. On the other hand, the European visitor is struck by the absence or primitive condition of the ordinary roads, to which comparatively little attention is paid in the country districts. Canadian roads are rarely macadamised, except, of course, in the towns and cities. "Dirt" roads suffice for the farmers' needs in the dry summer weather, and all heavy hauling by road is naturally carried out in the winter, when, at a very slight cost for labour, snow roads can be made, along which enormous loads can be easily handled. This is but one example of the important part played by climatic conditions in determining the character of construction work.

The English engineer who visits Canada will find much that is novel and unfamiliar. After a little study he becomes aware that the conditions obtaining in a young and rapidly developing country lead to a standard of correct construction somewhat different from the one to which he has been accustomed. In general terms it may be said that by nature and by training the engineer in Canada is induced to think first of low cost and rapid completion of work, and he attaches less importance to permanence in a structure, or to durability in a machine, than does his confrère in an older country. It must not be understood from this



RAILWAY MAP OF CANADA.

that a Canadian will not pay the price of first-rate work and material when these are seen to be necessary for commercial efficiency, but he fails to understand, for example, why an English railway should insist on what seems to him a lavish expenditure of paint and varnish on its locomotives and tenders, when no immediate result in lessened cost of operation or repairs is apparent. The large amount of engineering work of different kinds required in proportion to the population, the necessity in many cases of using cheap and perishable material if the work is to be carried out at all, and the brief period in which many schemes are likely to become obsolete, are all influences tending in the same direction. Similar conditions exist generally in the United States, but there, especially in the Eastern States, and in Canada too, we find a growing tendency towards more expensive and permanent work. On the other hand, the public safety is not so jealously watched in Canada as at home; people are more largely left to themselves for protection from accidents, and this freedom from legislative trammels renders it possible to carry out successfully schemes which in England would be often rendered impossible by the sheer weight of governmental or municipal restrictions.

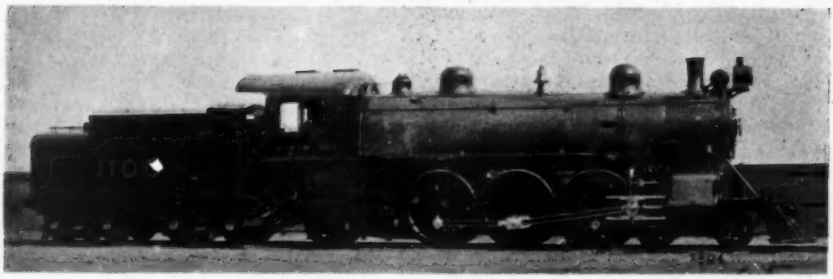
Railway Engineering.—The earnings from passenger traffic on Canadian railways are as a rule about one-third of those derived from the movement of freight, and the railway systems are naturally inclined to look upon freight traffic as their chief *raison d'etre*. The aim of nearly all recent engineering work in connection with the existing Canadian railways has been to facilitate the eastward movement of the great cereal crops of the west, and in return to carry cheaply to the agricultural regions the people and supplies they require. The Grand Trunk Railway, for example, having at present no direct communication with the west of Canada, has sought to better its position by improvements on a large scale, the reduction of grades, the provision of heavier locomotives, and the establishment of facilities for the interchange of traffic, and the prompt handling of material. This road, working a system extending from Portland (Maine) through Montreal to Toronto and Chicago, with connections to the shipping ports of Medland and Collingwood on Lake Huron, has, of course, intimate relations with the roads of the United States, and by the acquisition of the Canada Atlantic Railway it has now obtained a through connection under its own control from Montreal to Parry Sound, a third port on Lake Huron to which large steamers can economically bring grain from Lake Superior ports. In 1905 the Grand Trunk Railway received about 30,000,000 bushels of grain by this route.

In 1903 the Dominion Parliament passed the Act incorporating the Grand Trunk Pacific Railway Company, the stock of which is eventually to be acquired by the Grand Trunk Railway Company. The lines thus contemplated and under construction will form a new transcontinental line about 3,600 miles in length (branches included); the western terminal, Prince Rupert, on the Pacific coast, being connected through Winnipeg to Quebec, and thence to the maritime provinces. There will be a branch from the main line southerly to Fort William and Port Arthur on Lake Superior, which will, of course, be used for shipping grain during the season of navigation. The cost for the entire main line is estimated at about £25,000,000 sterling; the contracts for about 900 miles are already let, at prices which are within the estimates. In connection with this transcontinental line, the traffic across the St. Lawrence will be carried by the great cantilever bridge now approaching completion near Quebec. This bridge has a channel span of 1,800 ft., with a clear headway for shipping of 160 ft. at high water.

In the construction of the Grand Trunk Pacific every effort is being made to ensure economy of haulage, and it is stated that grades not exceeding 0·4 per cent. in the eastern and western sections, and 1·0 per cent. in the mountain section, can be secured. The pass by which the road will cross the Rocky Mountains has a summit level of about 2,500 ft., as compared with the 5,300 ft. of the Canadian Pacific, and the much greater heights reached by some of the roads in the United States. Everything points to success in the completion and economical operation of this great enterprise.

Other railroads are making preparations to invade, or are actually entering, the new wheat producing districts of the North West. The Canadian Northern, for example, whose main line now reaches Edmonton, is about to move north-westwards from that point. Its builders control a number of shorter lines in other parts of the country, which it is hoped will eventually be linked together to form a third transcontinental line. From the United States, the Great Northern is extending branches with a view of obtaining Canadian traffic.

In the early days of the Canadian Pacific Railway some pessimists were of opinion that the road would do well if it ever earned enough money to pay for its lubricating oil. These dismal anticipations have proved very wide of the mark. In the month of March,



CANADIAN PACIFIC RAILWAY PASSENGER LOCOMOTIVE (4-6-2 TYPE). Built 1906.

Cylinders 21 ins by 28 ins stroke; driving wheels, 75 ins. diameter; working pressure, 200 lbs.; total heating surface 2957 sq. ft.; grate area, 45·6 sq. ft.; superheater surface, 528 sq. ft.; weight of engine and tender loaded, 334,700 lbs.

1906, for example, the Canadian Pacific Railway showed a gross revenue of over £1,000,000, and a net profit of about £370,000, an increase of £130,000 over March, 1905. It must not be supposed that the Canadian Pacific has been standing idle while the Grand Trunk Pacific and Canadian Northern schemes have been in process of development. The Canadian Pacific Railway now operates more than 11,000 miles of line, 500 miles of new branches are at present being built, there will soon be a double track from Fort William to Winnipeg, permanent structures are replacing those of cheaper construction, and enormous sums have recently been spent on shops at Montreal and Winnipeg and on terminal facilities at various points.

The Angus shops of the Canadian Pacific Railway at Montreal were completed in 1905, employ some 4,000 men, and are designed for the construction of 100 new locomotives per annum, and for the repair of 400 old ones at the same time. They can build, in addition, 30 freight cars per day, and all the passenger cars necessary for the system. The wheel foundry turns out 300 wheels per day. The works site has an area of 200 acres, and the buildings and equipment have cost about £800,000. The Winnipeg shops, which are intended to deal only with the locomotive and car repairs of the western end of the road, are on a smaller scale, but are equally complete.

The Canadian Pacific alone among the railways of Canada builds practically all of its rolling stock. The Grand Trunk builds most of its own engines and possesses large works for this purpose and for repairs at Point St. Charles, Montreal. The needs of this and other roads have led to the establishment within the last three years of such works as those of the Locomotive and Machine Company of Montreal, and the Canada Car Co. The two firms just mentioned have their works in Montreal, and can turn out, the one 200 locomotives and about 12,000 tons of structural steelwork per annum, and the other 20 freight cars per day and 100 passenger cars per year. Locomotives are also built at Kingston, Ontario, and at the shops of the Canada Foundry Co., Davenport, Toronto, which have been recently built and equipped.

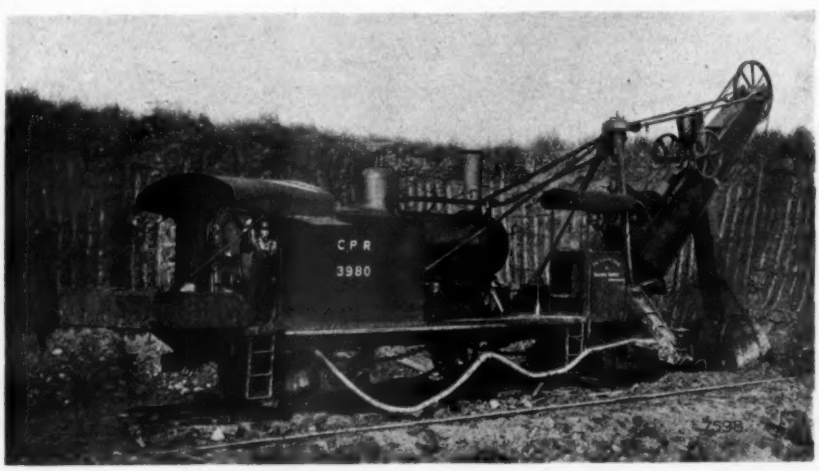
Locomotive practice in Canada is generally similar to that of the United States. Trains of the same kind have to be hauled, although the severe climatic conditions make traffic more difficult to handle in winter in Canada than is the case in most parts of the United States. For this reason the winter rating of engines is, of course, less than would be possible in a milder climate, and the use of the snow plough and the clearing of the line during a severe snowstorm make demands on the motive power department that are not experienced to the same extent further south. Perhaps

the most interesting feature of recent locomotive work in Canada has been the adoption of superheaters by the Canadian Pacific, on a considerable scale. Freight engines of 4-6-0 and 2-8-0 types fitted with superheaters have undergone extensive series of tests in actual service on various divisions of the road, with results which show a substantial saving in running expenses, varying from five to twenty-five per cent. as compared with simple engines and two cylinder compounds using saturated steam. The Canadian Pacific has, in fact, been the pioneer in the use of superheating for locomotive purposes in North America.

Steel rails are manufactured at the works of the Dominion Iron and Steel Co., Sydney, C.B., where about 36,000 tons were rolled in 1904, and also at Sault Ste. Marie, Ontario. It is estimated that about 1,000,000 tons of rails will be required in Canada within the next five years for new construction alone.

In discussing the transportation facilities of Canada, the development of the street railway systems of the large cities must not be forgotten. Although the Canadian winter is not without its drawbacks from the point of view of the motive power department of either a steam or electric road, the provision of powerful ploughs and sweepers enables the street railways, like the steam roads, to carry on their work with but little inconvenience and delay even during the hardest winter.

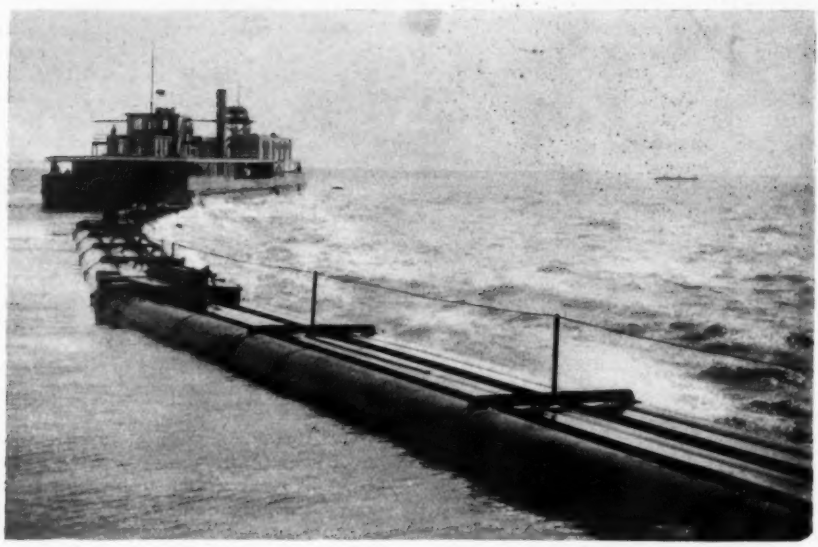
The two largest street railway systems are those of Montreal and Toronto, comprising about 130 and 100 miles of track respectively. The Montreal Company owns its own car shops, and has recently supplemented the equipment of its original steam-driven power station of 4,000 i.h.-p. by the addition of new engines of 6,500 i.h.-p., together with the necessary boiler plant. A supply of electric power to the amount of 8,000 h.-p. is drawn from Shawinigan and from Chambly, and contracts have just been let for the construction of a second large steam station. The Toronto



STEAM SHOVEL FOR THE CANADIAN PACIFIC RAILWAY CO.

Built by the Locomotive and Machine Co. of Montreal, Ltd. Fifteen of this type now in use on the C. P. R.

Capacity of bucket, 3½ cubic yards; rate of work, four to six buckets per minute; total weight in steam 70 tons; width of cut, 60 ft.; will load into cars on bank alongside.



HYDRAULIC DREDGER "J. ISRAEL TARTE," FOR THE DEPARTMENT OF PUBLIC WORKS, OTTAWA, FOR WORK IN LAKE ST. PETER.

Built by the Polson Ironworks Co., Toronto, Ont.

Width of cut, 700 ft.; capacity, 2,000 cubic yards per hour; length of discharge pipe, 2,000 ft.; main pump discharge pipe, 36 ins. diameter; main pump engines, 1,200 I.h.-p.; depth of water, 35 ft.; material, blue clay.

system has undergone corresponding growth.

The capital invested in the street railways of Canada is now about £7,000,000. The tendency so noticeable in the United States, to construct suburban lines of considerable length, often paralleling steam railways and competing successfully with them, is beginning to make itself felt in the Dominion also.

Waterways and Harbours.—The waterways of Canada afford communication from the Atlantic to the end of Lake Superior, a distance of about 1,300 miles from Montreal. Although the season of navigation is limited to some 220 days per annum, the river and canal system of the country is of vital importance, as the rates charged for water transportation control those of the competing railways. The inland navigation facilities are under Government control. There is now a depth of at least 28 ft. of water in the ship channel from the sea up to Montreal, and 14 ft. from that point onwards. This result has not been attained without a large amount of dredging, and work is still going on in the St. Lawrence below Montreal, in straightening the channel and widening it to 300 ft. at all points. The character of the machinery employed in this work may be judged from the performance of the dredger "J. Israel Tarte," built in Toronto in 1901, and designed for work in Lake St. Peter. This dredger is of the hydraulic type, and has removed 757,000 cubic yards of blue clay per month, at a cost of about $1\frac{3}{4}$ cent per cubic yard. In all probability, by the time the St. Lawrence ship channel has been completed to the dimensions at present contemplated, the size of ships

coming up to Montreal will have increased so much that the work will have to be commenced again, with a view of obtaining at least 35 ft. of water, with a corresponding increase in width.

A considerable amount of new work has also been done in connection with the 14-ft. channel of the St. Lawrence above Montreal. The Soulanges Canal, 14 miles long and surmounting a rise of 82½ ft. in passing from Lake St. Louis to Lake St. Francis, was completed in 1903. It has five locks worked by electric power; and the whole is lighted electrically so as to permit of vessels passing at night. The lock pits are 280 ft. by 45 ft., and it is not uncommon to see a vessel with only a few inches to spare passing through. The total cost of the Soulanges Canal was about £1,350,000.

The Trent Valley Canal, which will form a direct communication between Lakes Ontario and Huron, taking, however, barges of 8 ft. draft only, is interesting as including an hydraulic lift lock 140 ft. by 33 ft., with a rise of 65 ft. This was completed in 1905, and its working has proved satisfactory.

Several extensive additions to, and improvements of, the Canadian Canal system are now in contemplation, and the importance of this work to the country at large may be estimated from the fact that the St. Lawrence Canal system above Montreal is used annually by about two million tons of shipping.

In connection with the transportation systems of Canada, it should be remarked that within the last few years much has been done to improve the shipping facilities of the great ocean ports, of which Montreal is the chief. Since 1900 the harbour of Montreal has been completely transformed, a large amount of additional berth space for sea-going steamers has been provided, and the necessary sheds, grain elevators and railroad connections have been built. Quebec has not been stationary, and it is quite probable that as the size and number of vessels trading to the St. Lawrence is increased, Quebec will be the port for a considerable number of the larger vessels, say those over 15,000 tons. The new Empress steamers of the Canadian Pacific Railway will, for example, be berthed at Quebec, and, for the present, will not go up the river to Montreal.

During the time when the St. Lawrence is closed by ice, from the beginning of December to the end of April, St. John (New Brunswick) and Halifax are used by the Atlantic steamers. The results of ice-breaker experiments now being made in the St. Lawrence, with a view of lengthening the season of navigation, are awaited with great interest, although so far they have not been altogether successful. Larger and more powerful ice-breakers now under construction will perhaps enable this very desirable result to be attained, but it does not seem at all likely that Quebec can be kept open during the whole winter. Even if this could be done, it is doubtful if the extra cost of insuring vessels and cargoes, and working the ice-breakers, would not be so great as to make the scheme impossible commercially.

Bridge and Structural Engineering.—The construction of bridges in Canada (as in the United States) is carried on by companies who usually work out their own designs for any given case, and who are afterwards responsible for the manufacture and erection of the structures. Bridge builders also make steel work for buildings, and have at their command facilities for the rapid design and completion of work of this kind. As a rule, American sections of steel are used in preference to British Standard sections, as the former are found to be more economical. The quantity of steel used for bridges and structural work in the Dominion was, in 1895, only about 12,000 tons; in 1905 the construction amounted to something like 60,000 tons, of which only about 1,200 tons was imported as finished bridge or structural parts. The capacity of the various Canadian bridge and structural shops is now about 90,000 tons per annum and is being rapidly increased.

RAILWAY AND HIGHWAY BRIDGE OVER THE FRASER RIVER, NEW WESTMINSTER, BRITISH COLUMBIA.

(Built by the Dominion Bridge Co., Montreal.)

Consists of six spans, each 159 ft.; one swing span of 380 ft.; one fixed span of 380 ft.; and one spread span of 225 ft.

Apart from the great Quebec bridge, previously mentioned and approaching completion, the Victoria Bridge over the St. Lawrence at Montreal is perhaps the most interesting of the newer structures in Canada. It consists of 25 truss spans, and replaced the old bridge of the tubular type which did good service from 1860 to 1897. The total length is 6,592 ft., and the bridge carries a double track railway and two roadways. The centre span is 330 ft., and the side spans are from 242 to 247 ft. each in the clear. The headroom to underside of bridge is 60 ft. from the water level; the original piers with slight alterations were used for the new superstructure. The weight of the new steelwork is about 22,000 tons, and the whole work was completed in 1898. The longest time during which traffic was interrupted during the erection of the new work was two hours, and the total time lost in this way did not amount to more than 20 hours. The trusses and cross girders of the new bridge were erected outside the original tubes; the latter were then cut through and the rails supported from the new cross girders, and, finally, the old tubes were removed plate by plate.

Coal and Iron.—A bounty on pig-iron, steel rails, and structural steel manufactured in Canada has been given by the Dominion Government for some years. It is paid under somewhat complicated arrangements, and at a rate which is arranged to diminish from year to year, having been originally in the neighbourhood of $2.00 per ton. The production of pig-iron by the fifteen blast furnaces in Canada was about 60,000 tons in 1896, and will probably reach 400,000 tons this year, although the bounty has now been reduced to about 50 cents per ton. A corresponding increase has occurred in the production of steel rails, plates, and structural shapes. There are now eighteen completed rolling mills and steel

works in Canada, and five others under construction and projected.

An equally striking growth is apparent in the production of coal. This has risen from 3,500,000 tons in 1896 to about 9,000,000 tons in 1905. The country, however, does not yet furnish all the coal it needs, as almost an equal amount is supplied from the United States and Great Britain. The bulk of coal burned in Canada comes from Nova Scotia and British Columbia, from the extreme east and the extreme west of the Dominion. Much of the coal imported from the United States is anthracite, which is found but sparingly in Canada. It is confidently expected that additional coalfields will be found and worked in some of the districts which will be opened up by the railways now under construction. Large areas are known in the far north, but are as yet undeveloped, while recently much active work has been done in opening up new coalfields in Alberta.

Water Power Development.—A region of rounded hills, reaching a maximum height of some two thousand feet, begins on the Atlantic coast in Labrador, and extends along the north of the great lakes almost as far west as Winnipeg. It is a country of lakes and rivers, of dense bush and tangled swamp, and it forms not only a great timber-producing area, but its rivers and lakes constitute an almost untouched reserve of water power. A few of its great water falls have already been, or are now being, utilised, as, for example, at Shawinigan

HYDRO-ELECTRIC PLANT AT SHAWINIGAN FALLS, ST. MAURICE RIVER, P.Q.

Head of water, 135 ft. (will be increased to 150 ft.).
Turbines: one 9,000 h.-p., three 5,000 h.-p. each, two 550 h.-p. each (exciters).
Generators: one 6,600 kw., three 3,750 kw. each, two 400 kw. each (exciters). All direct connected.
Main generators give two-phase current at 30 cycles and 2,200 volts.
Transformers (water-cooled) give 25,000 volt two-phase current for distances up to 20 miles, and 50,000 volt three-phase for greater distances. Greatest distance of transmission, 84·3 miles.
Electric power is also developed by separate plants at Shawinigan for the work of the Northern Aluminium Co., and for pulp making and other industries. The total power developed for all purposes will eventually be some 80,000 h.-p.

on the St. Maurice River, and at Kaministiquia near the north shore of Lake Superior, at Ottawa, and at Montmorency near Quebec; while from the St. Lawrence itself power is being drawn at Niagara and at Lachine, just above Montreal. These developments have almost been carried out in the last ten years, and they are all within reach of manufacturing or commercial centres; it is, in fact, the feasibility of transmitting power economically over distances of one hundred miles or so, which has rendered these sources of supply available. Most of the power plants referred to have already been described in technical papers, and it is impossible here to do more than refer briefly to their general characteristics. A table showing some of the principal hydro-electric plants in Canada is appended. As an example of the kind of work involved in such enterprises, some particulars of the Kakabeka Falls plant now being constructed on the Kaministiquia River may be given, although there are many other works of equal technical interest. The installation just mentioned is of moderate size, and is designed for five electrical units (one spare) of 5,000 h.-p. each, the available head of water being 175 ft. The turbines have horizontal shafts and are directly connected to the alternators. The water from above the falls will be led into three circular armoured-concrete pipes, each 10 ft. in diameter and 6,000 ft. long. At the delivery end of these pipes is a concrete open-top penstock with syphon overflow, and from the penstock five steel pipes, each 7½ ft. diameter and 800 ft. long, leading the water to the power-house. The turbines are in pairs, one pair to each unit, and deliver into a central draft tube. They are of European manufacture, but the rest of the machinery is Canadian. In such a plant, as also in the much larger station of the Ontario Power Co. at Niagara, a very interesting feature is the overflow, intended to avoid shock and to permit of the escape of the moving column of water in the long inflow pipe should the turbine governor suddenly close its gate. The electrical equipment of the Kakabeka Falls plant

PRINCIPAL HYDRO-ELECTRIC PLANTS IN CANADA RECENTLY CONSTRUCTED.

Name.	H.-P.	Voltage.	Head ft.	Distance transmitted miles.	Power supplied to.
Canadian Niagara Power Co.	110,000	22,000 / 40,000 / 60,000	165	—	U. S. points.
Electrical Development Co. of Ontario	125,000	40,000 / 60,000	170	85	Toronto.
Ontario Power Co. ...	70,000	30,000 / 60,000	175	—	Partly to U. S.
Shawinigan Water and Power Co.	80,000	50,000	150	10 to 84	Shawinigan, along line, and Montreal.
Chambly	20,000	25,000	30	22	Montreal.
Lachine Rapids Land and Hydraulic Co.	8,000	4,500	11	4½	Montreal.
Soulanges	20,000	50,000	70	30	Montreal.
Kaministiquia Power Co.	20,000	25,000	175	18	Fort William and Port Arthur.
Ottawa and Hull Power and Manufacturing Co.	12,000	2,200 / 10,000	35	1 to 6	Ottawa and District.
Hamilton Cataract Power and Light Co.	30,000	22,500 / 45,000	265	34	Niagara District and Hamilton.
West Kootenay Power and Lighting Co.	30,000	60,000	70	60	Kootenay District B. C.
Huronian Co.	12,000	35,000	85	30	Copper Cliff, Ontario.
Winnipeg Electric Ry. Co.	30,000	60,000	42	65	Winnipeg.

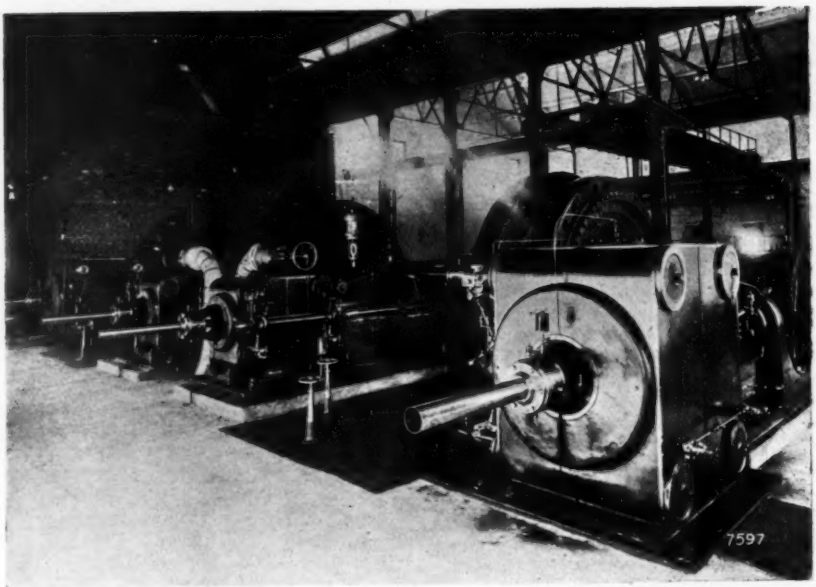
involves an 18 mile transmission, at 25,000 volts.

In glancing over the list of hydro-electric developments carried out in Canada during the past ten years, it becomes evident that an immense influence must be exerted by these undertakings on the industrial growth of the country. When we reflect that within a radius of forty-five miles from the city of Ottawa it is estimated that nearly 1,000,000 h.-p. can be rendered available, and that in many other parts of the Dominion equally favourable conditions occur, it is obvious that we are only at the beginning of the development and utilisation of the water powers of the country.

Municipal Engineering. — The urban population of Canada is about 30 per cent. of the whole, as compared with about 37 per cent. in the United States. This proportion tends to show an increase, so that as time goes on questions of municipal and sanitary engineering assume greater and greater importance. Water supply is now receiving the same careful attention that it obtains in older countries, although in most Canadian towns but little difficulty is found in securing a good and cheap supply. Sewerage, lighting, and fire-protection works are constantly being constructed or extended. As an example of what is being done in these branches of engineering the new waterworks at Winnipeg may be cited. These have been carried out by the municipality, and are capable of supplying 10,000,000 gallons per twenty-four hours from four large deep wells situated some seventeen miles from the city. The whole supply is softened and filtered before distribution. The water of the Red River, and of the Assiniboine River, was found to be so polluted as to be unreliable as a permanent source of supply of potable water; the Red River, however, is used to furnish water for a separate high-pressure fire-protection system. This comprises at present about three miles of pipe, carrying water at 300 lbs. pressure and fed by reciprocating pumps delivering about 500,000 gallons per hour, and driven by "Crossley" gas engines of 2,600 b.h.-p.

In Toronto, a similar fire-protection system is now under construction, but it is of somewhat smaller capacity, being supplied by two 2-stage high-lift turbine pumps, each directly connected to a 1,000 h.-p. "Westinghouse-Parsons" steam turbine. The pumps can be used as single-stage pumps if required, giving in this case 150 lbs. pressure instead of 300.

Mechanical and Electrical Engineering.— When we turn to what may be termed the manufacturing side of engineering development, we find that marked changes have passed over Canada during the period under review. Ten years ago, for instance, the value of the products of the firms engaged in the manufacture of electric appliances and supplies was only about £200,000 per annum; it is now estimated at nearly five times that amount, although the returns for 1905 are not yet available. The output of steam engines and boilers has doubled in the same time. As has already been pointed out, a portion of this manufacturing growth is undoubtedly due to the establishment of Canadian branches by both large and small firms from the United States; this example has only been followed to a very limited degree by the manufacturers of the old country. With a few exceptions, English mechanical and electrical engineers have done little towards securing for themselves a share in the large amount of work that has been going on in Canada, and they have been completely distanced by the enterprise and energy of the Americans, who naturally endeavour to monopolise the business of supplying machinery of all kinds to their near neighbours. In 1903 the value of dutiable articles of iron and steel (including machinery) imported into Canada from the United States was £4,000,000, while Great Britain supplied such articles to the amount of £1,400,000 only, in spite of the preference of 33 per cent. in duty, and the fact that the rates for ocean freight are generally less than the railway charges from United States



DIRECT CONNECTED ENGINES AND GENERATORS, HAMILTON POWER, LIGHT, AND TRACTION CO., HAMILTON, ONTARIO.

(Built by the Goldie and McCulloch Co., Ltd., Galt, Ontario, and the Canadian Westinghouse Co., Hamilton, Ontario.)

Cylinders, 28 and 52 ins. dia. by 46 ins. stroke; i.h.-p., 1,500 at 100 revolutions per minute; working pressure, 150 lbs. generator, 1,000 kw., 8,000 alternations.

points to Canada. It does not seem likely that the Canadian machine shops and electrical works will be able to supply their home demand for many years to come, rapidly as their production is increasing, for the requirements of the Dominion are increasing at a still greater rate. British engineering firms, therefore, have yet time to make up some of their leeway.

Several of the Canadian engineering works dealing especially with railway requirements have already been mentioned, but in order to give a more general idea of the engineering resources of the country from the mechanical and electrical point of view, brief reference may be made to some others which have been established or have developed during the last few years.

The growth of the Canada Foundry Co. is an example. It is affiliated to the Canadian General Electric Co., of Peterboro', Ontario, a firm having close relations with the General Electric Co., of Schnectady, New York. The shops of the Canada Foundry Co. were established in 1900, now cover six acres of floor space, and employ some 2,000 hands; they build locomotives, stationary and marine steam engines and boilers, steam shovels, cranes, and pumping and air compressing machinery, and have also the necessary modern facilities for bridge and structural work. Similar development is shown by the Goldie and McCulloch Co., Ltd., of Galt, Ontario, who build chiefly stationary engines and boilers, and machine tools. They report that their output has increased since

1905 by about 70 per cent. In Nova Scotia, The Robb Engineering Co., of Amherst, builders of steam engines and boilers; in Ontario, the John Bertram & Sons Co., Ltd., of Dundas, machine tool makers, and the Waterous Engine Works of Brantford, give similar accounts of rapid progress. Shipbuilding is being carried on in Toronto, and in Collingwood on Lake Huron, and the list of mechanical engineering firms might be largely extended.

In electrical engineering the greater portion of the work done in Canada is now in the hands of firms which are closely connected with, and are practically offshoots of, the large companies in the United States. The Canadian General Electric Co., of which mention has already been made, purchased its works at Peterboro', Ontario, in 1892. They cover about 45 acres of land and employ some 1,500 men, building electric generators, motors and transformers of all types, and constructing also controllers, switch boards, lamps and electrical accessories. The building of steam turbines of the "Curtis" type is now being added to the work of this company.

The factories of the Canadian Westinghouse Co. at Hamilton, Ontario, carry on a similar business, together with the manufacture in Canada of the "Westinghouse" air brake apparatus. Their works now employ about 1,000 men, and commenced operation about ten years ago. This company, while in close technical relations with the great Westinghouse Companies in the United States, has invested in it a large amount of Canadian capital, in which respect it resembles the Canadian General Electric Co.

Two years ago the Canadian branch of the well-known Allis-Chalmers-Bullock amalgamation was established, in a new factory at Lachine, some six miles from Montreal. Their products include electric motors and generators, together with air compressing and mining machinery; in fact, machinery of the various types associated with the names of the three American companies from whom the Canadian firm takes its title.

In an article of this kind it is manifestly impossible to give a detailed account of the changes that have occurred in all branches of engineering in the Dominion since 1896. Enough has probably been stated to show that the extent of the country, the activity of its people, and their rapid growth in wealth, together with the enormous natural resources available, all point out Canada as a country for which a great industrial future is assured.

Engineering Progress in Western Australia.

By WILLIAM LESLIE, M.I.Mech.E., M.Inst. Engineers and Shipbuilders in Scotland.

PROBABLY no country in the world has advanced so much, in so short a period of time, by the aid of the engineer, as Western Australia.

Within the short space of two decades it has sprung from a mere settlement—a few small inhabited areas along the Coast — to a busy State, having an annual import and export trade amounting in 1904 to £16,943,991, made up as follows :—Imports, £6,672,480 ; exports, £10,271,511.

That this enormous trade should be maintained by the comparatively small population as yet in the State is the wonder of all who seek to inquire into the subject. In 1895 the population was 101,143. At the 30th June, 1905, it was 251,126.

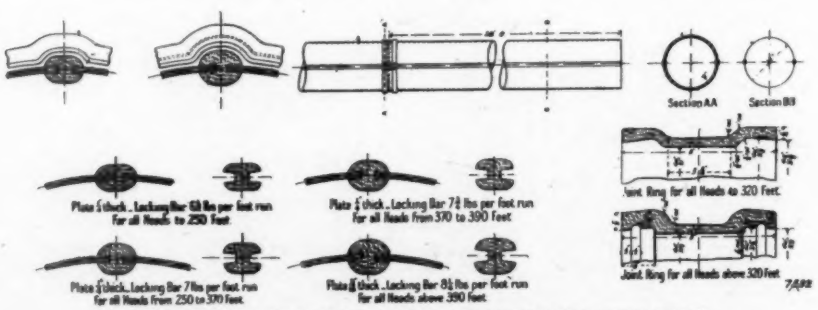
The State itself forms almost one third of the total area of the Commonwealth, and its very immensity must have been the despair of the early settlers.

The lands are generally heavily timbered. From the end of November until the end of April very little rain falls, and the river beds mostly become dry. Regular water supplies depend upon conservation. The rainfall is, however, very regular in the season, varying from 30 to 40 in. annually, near the coast; in the south-western districts where settlement has mostly taken place, to from 12 to 15 in., 130 miles inland. On the Goldfields it is irregular.

Exclusive of the mining and timber industries the engineering history of Western Australia is almost the history of its Public Works Department.

The timber industry being one that must of necessity pass away to give place to the agricultural and fruit industries, beyond stating that the annual export value of local-grown timber has grown from £88,000 in 1895 to £655,000 in 1904, I do not propose to deal with it here.

Water Supply. — Perth, the capital town, has a gravitation water supply, the source of which is the Darling Ranges, some 20 miles distant. It is now quite inadequate for the thriving capital, and is about to be augmented by a new supply from the same source, equal to 10,000,000 gallons per day. A concrete dam from 175 to 200 feet high will be built across the Canning River, and a 42 in. main laid. This supply will serve the whole of the metropolitan area.


Section AA
Section BB
Plate ⅜ thick. Locking Bar 5⅛ lbs per foot run for all Heads to 250 Feet
Plate ⅜ thick. Locking Bar 7¼ lbs per foot run for all Heads from 370 to 390 Feet
Plate ⅜ thick. Locking Bar 7 lbs per foot run for all Heads from 250 to 370 Feet.
Plate ⅜ thick. Locking Bar 8½ lbs per foot run for all Heads above 390 feet.
Joint Ring for all Heads to 320 Feet.
Joint Ring for all Heads above 320 Feet.
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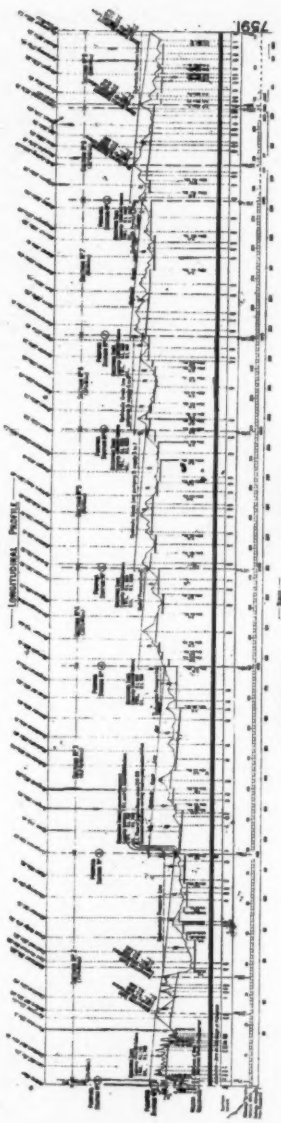
DETAILS OF LOCKING BAR PIPE USED FOR THE COOLGARDIE WATER SUPPLY SCHEME.

Fremantle, the shipping port, 12 miles distant from Perth, is at present served with a supply drawn from wells and drives in the limestone rocks in the vicinity, but it is not satisfactory and will be included in the service of the new scheme. The suburbs are supplied from bores, but the water is generally of a poor quality for domestic use. The new supply will replace all the existing present supplies.

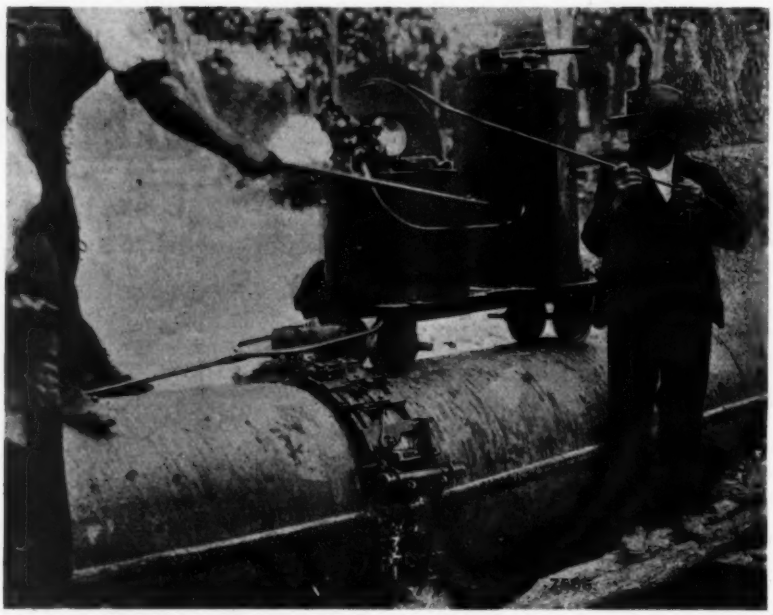
Shortly after the discovery of the Coolgardie Goldfields and on the advent of the opening of the railway to Coolgardie, Sir John Forrest, the then Prime Minister of the Colony, announced the intention of the Government of providing a supply of water for the Goldfields, at an estimated expenditure of £2,500,000, and this scheme has since been put into execution. Without doubt this is one of the boldest undertakings ever conceived and successfully carried out. It consists of a construction of a concrete weir, across the Helena River, in the Darling Ranges, about 30 miles from the coast, forming a reservoir seven miles long having a capacity of 4,600 million gallons. The laying of a 30 in. diameter steel main 352 miles in length to Kalgoorlie alongside the railway line, and the construction of eight pumping stations placed at suitable distances along the pipe-line. The difference in level between the reservoir at the source, and the main distributing reservoir at Coolgardie is 1,290 ft. The scheme has been designed for the supply of 5,500,000 imperial gallons of water per 24 hours to the Goldfields, and when the pumps are delivering this supply, the total head, divided between the eight pumping stations, is 2,500 ft.

Since the opening of the scheme in January, 1903, the consumption of water has steadily increased from 361 million gallons in 1904 to 510 million gallons in 1905. The consumption for 1906 is estimated to reach close on 600 million gallons. During the year ending 30th June, 1905, the revenue was £141,067, and the expenditure £42,835, leaving a gross profit of £98,232. This was sufficient to pay interest and sinking



COOLGARDIE WATER SUPPLY: LONGITUDINAL PROFILE OF PIPE LINE.

R.L. denotes reduced level; T.W.L. denotes top water level; O.L. denotes offtake level.



LEAD RUNNING APPLIANCE USED ON THE PIPE LINE OF THE COOLGARDIE WATER SUPPLY.

fund on £178,000, spent in reticulation, and interest on £2,636,000, the actual capital cost of the scheme. The sinking fund, amounting to £81,000 on the capital account, being made up from the Consolidated Revenue of the State. Against this, the government railways have been able to effect such substantial savings on their water supply, as would probably amount to about half the contribution from the Consolidated Revenue.

When the consumption reaches four million gallons per day the scheme will be within measureable distance of becoming self-supporting.

A novel departure in the construction of the pipe-line was the use of the locking-bar pipe. These pipes had only been tried in one gravitation main before being adopted for this scheme. With the exception of some miles in the Avon Valley, where the pressure is 500 feet head, and the pipes are made from $\frac{5}{16}$ in. plates, the whole main throughout is made from steel plates $\frac{1}{4}$ in. thick.

The plates were delivered in the State in sizes 28 ft. long by 4 ft. wide. They were then planed on the edges, and upset with a special machine, to form a dove-tail. Afterwards the plates were bent to a half circle. One locking-bar, 28 ft. long, with a grooved edge on each side to receive the dove-tail, was placed between the two half-circled plates and temporary clamps were put round to keep the whole together until the edges of the locking bars were closed under heavy hydraulic pressure over the dove-tailed edge of the plates. The pipes are thus rivetless.

Special machinery was designed and laid down in the State for their manufacture. Both locking bars, by means of a mandrel, were closed at one operation. The pipes are heavily coated with bitumen and are giving good satisfaction. The main is laid underground the whole

way with the exception of some $4\frac{1}{2}$ miles which pass through salt lakes country, when it is carried on wooden trestles.

The joints are solid welded double collars. In the lead running of the joints an internal expanding ring was employed to keep the lead from getting into the pipe, no oakum being used behind the lead. The lead was melted by means of a kerosene torch in a portable lead pot which ran along the top of the main. Special running sleeves were used for putting round the pipes and jointing collars. The lead-running pot had two gates at the bottom, one for each side of the jointing collar and the joints were run very quickly.

The caulking was done by hand, round the locking bars and a few inches on each side. Between the locking bars the caulking was done by electrically driven caulking machines, consisting of a light cast steel frame work having a revolving ring on each side driven by worm gearing, and carrying a series of rollers sufficiently narrow to follow up the lead. These rings were revolved until the rollers came close to the locking bars, when the motor was reversed and a screw tightened up which brought the rings carrying the rollers closer together, and this was repeated until the joint was sufficiently caulked. About 9 in. extra excavation under each joint served to give clearance to the caulking machine.

The weir at the source of supply is 755 ft. long on the crest, and 100 feet high above the bed of the Helena River. Some difficulty was experienced in getting a suitable foundation, owing to the discovery of a schistose reef in the bed of the river at right angles to the line of the weir, and the foundation had to be carried down 100 feet below the bed of the river before it could be pronounced safe. The width of this reef with its "Soapy Walls" averages from eight to

CAULKING MACHINE USED ON THE PIPE LINE OF THE COOLGARDIE WATER SUPPLY. THE CARRIAGE IS FOR CARRYING THE MACHINE FROM JOINT TO JOINT.

fourteen feet and about 10,000 additional yards of concrete were required to make the foundation good. Between the face of the concrete and the face of the reef on the upstream side good clay is well rammed, and in the bed of the river, over the clay, is placed twelve inches of concrete to prevent the fresh water crayfish from boring into the clay. The result has been entirely satisfactory and there is no leakage, although the weir, since its completion, has been overflowing several times, to a depth of two feet. The overflow is provided for by eight bays each of fifty feet in the clear and all are spanned by a steel foot bridge, five feet above the crest.

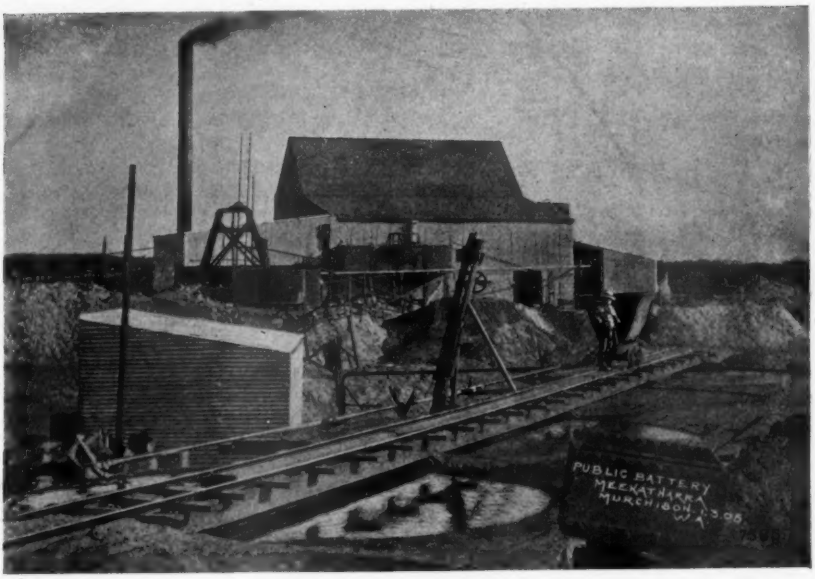
Mining. — Gold mining first commenced in the State in the year 1886. Between 1886 and 1897 it was continued in a desultory manner, mostly shallow workings and alluvial. The total recorded yield from 1886 up till December 1897 was 507,111 fine ounces, valued at £2,154,071. There is no doubt however that much gold was recovered during this period which was never recorded. In 1898 machinery and modern methods began to be applied. Since then the average value of the ore per ton has fallen considerably, but the reduced cost per ton of treatment has more than compensated for this.

The total yield up to the end of 1905 was 14,020,147 fine ounces, valued at £59,553,802.

The total area of the proclaimed goldfields in the State, at the end of 1904, was 315,089 square miles. The leases in force numbered 2,488, having an area of 32,530 acres. The total number of milling stamps at work was 4,000. There were 168 other mills, 1,308 leaching vats and 166 filter presses. The total number of men employed in the industry above ground was 7,926 and underground 8,922. The average value of gold yielded per man employed was £483 5*s*.

The industry is carried on exclusively with white labour and the rates of wages paid are higher than in any other country in the world, working under similar conditions. The class of labour is generally very good and is generally adequate to the demands.

COOLGARDIE GOLDFIELDS WATER SUPPLY. THE WATER OVERFLOWING THE CREST TO A DEPTH OF 2 FT.



STATE BATTERY, MEEKATHARRA, MURCHISON, WESTERN AUSTRALIA.

The highest class of motive power and machinery has been installed.

During 1904, Western Australia, which is sometimes spoken of as the Cinderella State of the Commonwealth, produced nearly 47 per cent. of the total gold production of Australia and New Zealand.

There is still a fair amount of prospecting work going on, on the fields. In December 1905 there were 1,395 men employed outside the regular mines in working alluvial and prospecting and their returns for the month were 2,329 fine ounces of alluvial gold and 438 fine ounces of dollied gold and specimens. A unique feature in connection with the gold mining of Western Australia, and one which has done much to prove claims, has been the establishment by the Government in various centres of what are known as State batteries. These batteries crush for the public at a fixed rate per ton. There are twenty-three of these erected averaging ten head of stamps each. Cyanide plants have been added at most of them to complete the extraction. About £200,000 has been spent by the State Government on their erection.

Since the first of them was erected in 1898, until the end of 1905, a total of 317,814 tons have been crushed with them for a yield of 366,044 fine ounces of gold, of a value of £1,352,965. During 1905 a total of 43,251 tons of battery tailings were treated by the State cyanide plants for a total value of £34,274, the cost of the treatment being £16,945.

In addition to gold, Western Australia yields silver-lead ores, copper and black tin. The annual value of the tin yield has risen from £25,270 in 1899 to £86,840 in 1905. On the other hand copper, which returned £55,270 in 1899, has declined. Doubtless the present high prices obtaining will lead to the opening up again of the mines in the Northampton and other districts

which have been closed down for some years.

The total coal yield to date since coal was first produced in 1899 is 377,187 tons, of which 127,362 tons were produced in 1905.

So far the measures being worked are in the Collie district only, situated about ninety miles south-east of Perth. The coal is largely used on the local railways. It has a calorific value of only 10,500 B.T.U. and contains a large percentage of moisture. It is not therefore suitable for export. There are other known measures, but these have not yet been proved.

Very little of the coal goes to the goldfields, where there is, for some years to come, an abundant supply of good firewood within convenient railage distance. Therefore, unless a coal suitable for export is discovered, the coal industry is not likely to make any great strides.

Harbour Works.—The finest and oldest harbour in the State is a natural one, viz., King George's Sound, on the south coast. For years the mail steamers plying between England and Australia made this the first and last port of call. Its great distance from the capital—340 miles—and the growing trade led the Government to construct a new inner harbour in the estuary of the Swan River at Fremantle, twelve miles below Perth. This was opened to the first vessel in 1897.

The harbour was commenced in 1892 and completed in 1902 at a cost of £1,500,000.

Previous to the construction of this harbour, the shipping was accommodated by a jetty extending about three quarters of a mile into Gage Roads, to the 3½ fathom contour, and by lighterage from vessels anchored in the roads.

The inner harbour is comprised of a basin about 4,500 ft. in length with wharves on both sides. For 2,150 ft., in the middle, this basin has a width of 1,400 ft. between the wharves, narrowing on the north side to 1,200 ft. at the upper end, and on both the north and south sides to 600 ft. at the entrance end. The entrance channel is 4,500 ft. long by 450 ft. wide, dredged to a depth of 30 ft. at L.W.M. It is protected on the north side by a rubble mole, extending the whole length of the channel, and by a short mole on the south side. The wharfage accommodation amounts to 9,000 lineal ft., of which about 8,000 has the full depth of 30 ft. alongside.

Altogether 1,500,000 cubic yards of rubber were used in the construction of the moles, and, with the exception of the outer 500 ft. of the north mole, which is granite rubble, the whole of this is limestone.

From the inner basin and entrance channel about 10,000,000 cubic yards of sand and rock were removed. The total rock dredging amounted to about twenty per cent. of the total, but much of this was sufficiently soft to be removed without blasting.

On the south quay nine transit sheds have been built, and a first instalment of electrically-driven cranes is now being provided.

Excepting a small slipway, which was built when the harbour was being constructed, for the accommodation of the dredges, there are, as yet, no facilities for dry docking vessels, but this defect is likely soon to be removed, the Government having offered to provide a floating dock capable of docking the largest vessels entering the harbour.

From the harbour at Fremantle, up to the Swan River to Perth, a considerable quantity of goods is carried by lighters, in competition with the railways, and as business is centering more and more in the Capital, it can only be a question of time when the shipping will come right up to the river to the Capital itself. Of the twelve miles, more than half is now sufficiently deep for vessels of 30 ft. draught, three-quarters of the distance for vessels of 22 ft. draught, and the remainder varies in depths from 6 up to 20 ft.

At the other outports shipping facilities are provided for by the construction of ocean jetties, that at Bunbury being protected by a granite breakwater.

Railways.—Up to the year 1887, when

gold was first discovered at Southern Cross, 236 miles east of Perth, and 115 miles west of Coolgardie, there were only 186 miles of railway in the whole of the State.

To-day there are 1,605 miles of railway, composed of 75 miles double line and 1,530 miles of single line, owned and worked entirely by the State, open for traffic, and 276 miles owned and worked by a private company. As the population is close on 250,000, this gives practically 75 miles of railway for each 10,000 inhabitants. In addition there are over 200 miles of privately owned lines, of a more or less temporary character, principally used in connection with the development of the timber industry. The 3 ft. 6 in. gauge is universal. The main lines are laid with 58 lb. rails, and the branches with 45 lb. rails. Local grown jarrah sleepers are universal. Their average life is from fifteen to nineteen years. The cost of a 9-in. by 4½ in. by 7 ft. hewn sleeper is 1*s.* 4½*d.*

The number of locomotives employed in connection with the Government railways is 326, four-wheel wagons 4,118, bogie wagons 1,916, break vans 138, and the number of carriages 326. The total train mileage for year ending 30th June, 1905, was 4,285,235.

About half the total railway system has been laid to develop and accommodate the mining industry, and the other half the agricultural industry.

On the Perth-Kalgoorlie run some of the best equipped trains in the world are to be found on a 3 ft. 6 in. gauge railway, and are not equalled on many standard gauge lines. The cars are built with side corridors both for first and second class passengers. Dining cars for both classes, and sleeping cars for first-class, are attached to the train. The cars are practically the same width as on the standard gauge, being 8ft. 9½ in. over all. They are electrically-lighted and well ventilated. The express makes the run of 375 miles in 15½ hours, so that the speed is slightly over 24 miles per hour, including all stoppages.

New railway workshops have just been completed at Midland Junction, 12 miles from Perth, at a cost of £450,000. The area of the site is 93 acres, of which there are at present 380,600 sq. ft. under cover. Provision has been made for extension of all the main buildings. Within the workshop area there are 16½ miles of railway lines laid, and the total number of workshop employees is 1,020.

In the main power house there is a battery of seven water-tube boilers, each of a nominal capacity of 160 h.-p. The boilers are equipped with mechanical stokers Economisers and superheaters are provided, the steam being superheated about 125° Fahr. The working pressure is 160 lb. per sq. in.

In the engine-room there are three 300 h.-p. high-speed compound condensing engines, each coupled direct to a 200 k.w. three-phase alternator, and two 90 h.-p. engines of the same class, each coupled to 60 k.w. three-phase alternators. The voltage is 220, and periodicity 50.

The three large alternators supply current for the whole of the machinery and cranes throughout the workshops, and the two smaller machines are used for lighting only.

There are 20 electric cranes provided, principally overhead, including 4 of 30 tons capacity, 1 of 20 tons, 4 of 15 tons, and 5 of 10 tons.

The machine tools are generally modern, although there are not many on which full advantage can be taken of the new high-speed steels.

The other equipment includes, two stage air compressers for operating the pneumatic tools, capable of delivering 570 cubic feet of free air per minute; compound condensing duplex steam pumps for hydraulic presses, operating at 1,700 lbs. pressure per square inch; and two three-cylinder blowing engines.

Occasionally, a little new carriage and wagon work is undertaken, but generally the workshops are wholly engaged in repairs.

About 100 miles of new lines are at present under construction as extensions to the present system, and some 500 more are projected as feeders in the

agricultural districts. The latter will probably be built to a lower standard of construction than the present lines. A separate line is also projected to start from the coast at Port Headland, about 1,000 miles north of the capital, and leading to the centre of the Pilbarra Goldfields, terminating at Nullagine, 178 miles from the starting point. This line will be a very valuable addition to the State Railways, and will open up a country nearly as large as France, not only already proved rich in minerals, but well occupied as pastoral country.

Trans-Australian Railway.—It would be incomplete to write on Western Australian Railways without mentioning this project. Outside Australia itself very few people are aware that, although Western Australia is a federated State of the Commonwealth of Australia, it requires four days' journey by ocean steamer, over very stormy seas, before one can pass to the next nearest State, South Australia. That is, of course, unless one travels overland, and under present conditions, of the two evils, the sea journey is infinitely the less. This isolation is, however, likely soon to be removed, and a railway constructed, by the Commonwealth Government, from the western terminus of the South Australian system, at Port Augusta, to Kalgoorlie, the eastern terminus of the Western Australian system. The total length remaining to be constructed, to complete the two systems, is 1,100 miles, and the estimated cost is £4,000,000 sterling.

Western Australia agreed to enter into federation with the other States of the Commonwealth, under a distinct promise, given before the referendum on the question was taken, by the South Australian Government, to co-operate with Western Australia for the construction of this railway and to pass legislation *pari passu* with Western Australia, giving the assent of the Government of the State to the construction of the line by the Commonwealth Government. The enabling legislation has been passed by the Western Australian Government, but it has not yet been passed by the South Australian Government. Of the mileage to be constructed, 625 lies between the nearest part of the South Australian system and the Western Australian border, and the other 475 lies between the border and Kalgoorlie.

There are no engineering difficulties, the country being mostly level plain.

Now that Australia has entered upon a second era of prosperity, by a succession of three good seasons, it is now confidently felt that a broader and more federal view is being taken, by the other States, of the immediate necessity for the railway, not only in justice to Western Australia, but in the interests of the whole Commonwealth.

Engineering in Queensland.

By THOMAS PARKER.

As the principal industries of the State of Queensland are the rearing of cattle and sheep, dairy farming, meat preserving, mining and sugar cultivation and manufacture, the engineering works of the country necessarily are more limited in range than those of communities of older settlement, or with larger manufacturing interests.

In connection with the first stages of development, railways and bridges figured largely in the lists of public works. All these constructions have been carried out by the State, although many of the bridges have been transferred to the control of Bridge Boards, or other local authorities. The railways are still in the hands of the State Government, and worked by a Commissioner for railways, whose office is secured from political influence.

Railways.—In the State there were 2997 miles of railways open at the end of 1903, and a few short branches have been constructed since. The total expenditure on these railways has been considerably over 21 millions sterling. The gauge of the Queensland railways is 3 ft. 6 in. Electric lighting has been installed at some of the stations in Brisbane, and Pintch's gas lighting has been introduced to the carriages on the Southern and Central Queensland lines. The carriages on the Northern lines have been fitted with Stone's electric light system. Most of the material for the railways has been imported from Great Britain, but in recent years several tank locomotive engines have been built in the State.

There are several small private railways in the country, but the total length of these is not large.

The whole of the building and repairing works for the State railways have been recently concentrated at Ipswich, near the capital city of Brisbane. The buildings cover a space of about fourteen acres, and cost about £384,000.

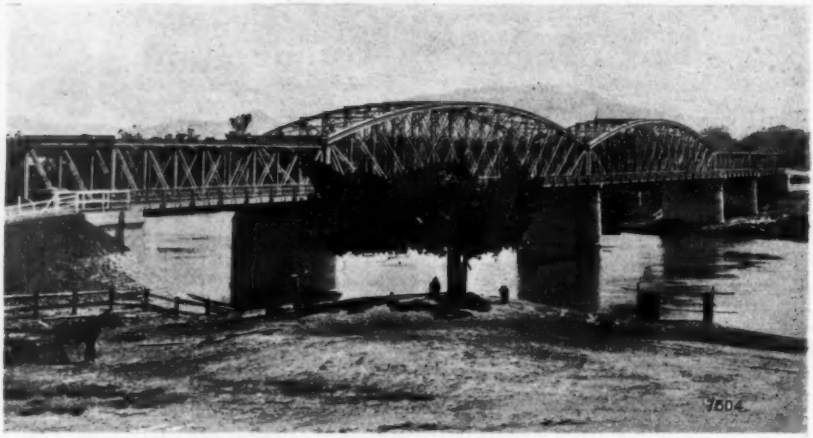
Motive power is furnished by Westinghouse engines of the single-acting, compound, condensing type, with 18 in. and 30 in. cylinders and 16 in. stroke, working at 150 lbs. steam pressure. There is a compound Riedler air compressor, driven by horizontal cross compound condensing Corliss engine, with a capacity of 1,000 cubic feet of free air per minute to a pressure of 100 lbs. per sq. in., and the plant also comprises a set of compound duplex pumping engines and a hydraulic accumulator of the Armstrong type.

The steam supply is from four Babcock and Wilcox boilers, arranged in two batteries, with Worthington feed pumps and surface condenser. The fires are fed by Hunt's conveying gear for coal and ash handling.

The workshops comprise boiler, machine and erecting shops, also wagon shops and saw mills.

The cranes and machines are electrically driven, and are more fully described under Electrical Engineering.

Bridges.—Some of the earlier bridges were destroyed by the great floods in the nineties of last century, and have been replaced by new structures. The Victoria bridge, at Brisbane, is a five span iron structure of the lattice girder type, with two roadways, and cost £112,000. It consists of six steel spans, each 170 ft. long, carried on five piers of cast iron cylinders filled with cement concrete. There are two carriage ways, each 24 ft. wide, and two footways of 9 ft. width. The decking is of steel trough plates covered with tarred block



ALEXANDRA BRIDGE, ROCKHAMPTON, QUEENSLAND.

paving. The total length of the bridge is 1,040 ft., width 73 ft., and the height from high water level is 34½ ft.

The Fitzroy Bridge at Rockhampton, is on the chain suspension principle, and was built in 1878. It rests on cast iron piers, has five spans of 232 ft. each, and has a height of 20 ft. above high water. The illustration represents the structure during a great flood in 1890, when it was partly damaged.

The Alexandra Bridge, at Rockhampton, is a recent work, of wrought iron, and spans the Fitzroy river. It carries two lines of railway connecting the city of Rockhampton with the port of Broadmount and Emu Park, one of the sea-side watering places of Central Queensland. There are several other similar structures on the railways of the State.

Harbour Dredgers.—The dredging of the three chief harbours of Queensland has, until recently, been carried out with steam power bucket dredgers of the usual type. About eight years ago, two powerful suction dredgers, by Sir Wm. Armstrong & Co., of Newcastle-on-Tyne, were imported. One is at work in the Brisbane harbour, and the other at Rockhampton.

Boring Artesian Wells.—Immense Artesian water supplies are found under the western plains of Queensland, and many Queensland engineering firms are engaged in the manufacture of boring plants. In particular may be mentioned Messrs. Burns and Twigg, of Rockhampton, who are sending out these plants, on the walking team principle, to various parts of the world.

The great extent in Queensland of this department of engineering industry may be gathered from the following statistics of the State. The total number of artesian wells sunk, 973. Total aggregate depth bored, 1,188,211 ft., equal to about 225 miles. The total number of flowing wells, 596. The aggregate daily flow, approximately, is 390,846,900 gallons. The estimated value of the 973 bores is £1,485,264. The deepest bore is at Bimerah; with a depth of 5,046 ft. and a flow of 70,000 gallons daily. The shallowest is at Manfred Downs, and is 10 ft. deep, with a flow of 2,000 gallons daily.

The tapping of these immense underground water supplies has been of the greatest advantage to the sheep and cattle stations of the far interior, when the water conserved on the surface frequently becomes exhausted during a season of drought. This artesian basin

extends over a large area of the interior of Queensland, where the normal rainfall is both low and uncertain. The official returns show that the Queensland area capable of furnishing artesian supplies, of greater or less volume, is, approximately, 376,000 square miles, equal to fully 56 per cent. of the total area of the State—viz., 668,497 square miles.

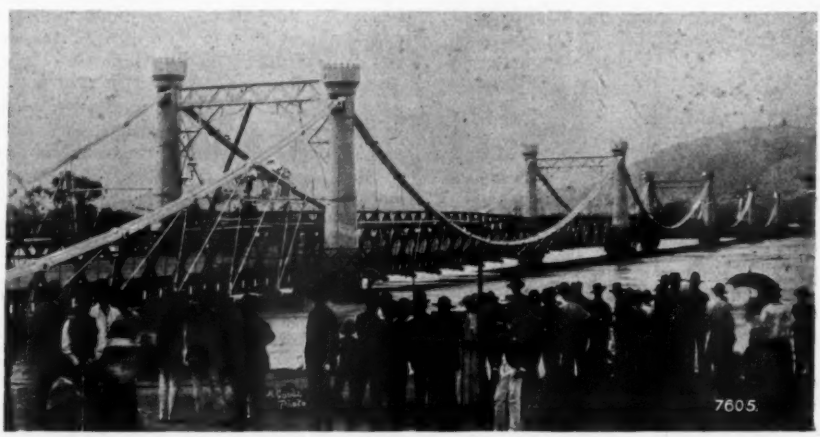
Meat Canning Machines.—Machines for putting compressed meat into cans are also made in Rockhampton. An illustration is given of a revolving machine made by Messrs. Burns and Twigg. There are five revolving fillers in this machine. The attendants weigh the meat and place it in hoppers at the lower part of the machine. There are two plungers for each can filler. A large plunger presses the meat into a hopper, and a small plunger, working within the larger, presses the charge of meat into the tin. The capacity is 1,500 cans per hour.

Plants of this description for meat works are also manufactured by Messrs. Smith and Faulkner of Brisbane, who also make digestors, extract machines, filter presses, embossing presses, retorts, and dies of all kinds.

These two Queensland engineers have gained great experience and skill in the design and construction of machinery dealing with the preservation of meat. Plants from their works have found their way to New Zealand and Western Australia, as well as to various parts of the State.

Sugar Mills and Refineries.—At Bundaberg, Mackay, and other sugar cane centres, there are large numbers of sugar mills of recent types. At the former town, the Milaquin Sugar Refining Works are the largest in the country. Here sugar and golden syrup are largely produced, and 90,000 gallons of cane juice can be treated daily. The sugar cane and juice are brought into the works by rail and punts on the river. Also by pipes laid underground to a number of the plantations of the district. There are also two other sugar refineries near this town.

Mining Engineering.—The state of Queensland possesses very large mineral resources, and mining for gold and coal have played an important part in the history of the country. The deposits of coal in the southern and central part of the State are very extensive, and the former have been worked for a number of years. The output last year was about 250,000 tons. Some of the seams are of great



FITZROY BRIDGE ROCKHAMPTON, QUEENSLAND.

thickness, and as an instance, may be named the New Swanbank Colliery, where a seam 14 ft. thick is being worked by a tunnel. At the Bogside mine the coal seam is worked in two sections, the top part by one body of miners, whilst another gang follow the first lot, and lift the bottom part of the seam. The portions of inferior material next the roof and the floor are not worked. The central portion of good coal is from 10 to 12 ft. in thickness.

One of the most important of the recent mineral discoveries in Australia is that of the large deposits of anthracitic coal in Central Queensland, near the port of Rockhampton. These deposits extend over about 5,000 sq. miles and the coal has been proved, by various tests and analysis, to be smokeless, and equal to the best Welsh steam coal. Some of the seams of this new coalfield are of great thickness, and as tests of the coal of a satisfactory nature have already been made, the development of the mines on a large scale at an early date appears to be assured.

At one of those mines, the Bluff Colliery, the coal has already been developed, the mine having been connected by a short line with the central railway to the port of Rockhampton. The coal is being delivered to various parts of Australia, some even having been sent to Newcastle (New South Wales), thus controverting the old adage about "coals to Newcastle." The seam which is being worked is 200 ft. from the surface, is 5 ft. 6 in. thick with a thin band of shale in the middle. The mining and winding appliances are only on a small scale at present. As orders for the coal are now beyond the capacity of the mine, it is intended by the company owning the mine greatly to enlarge the winding and other machinery.

There are two other mines being opened in the valley of the Dawson, where the coal is of even better quality. It is intended to raise a few hundred tons of this superior coal for a test by the Admiralty at Sydney. At another mine, the Wallaroo, in the same district, a splendid quality of coal has been struck. Tests of this coal, made in Rockhampton, show it to possess a calorific value of 14,243 British thermal units. Analysis shows it to contain: moisture, 1·7 per cent.; volatile hydro-carbons, 11·75 per cent.; fixed carbon, 78·25 per cent.; and ash, 8·2 per cent.

Gold Mining.—Gold mining has been carried on extensively since the foundation of the colony. A few notes may be made here on the practice prevailing in the engineering work of goldmining. At Croydon, Charters Towers, and Ravenswood, vertical shafts are generally sunk until the reef is intersected, and the development of the reef is usually carried on by underlay or incline shafts. At Mount Morgan and Gympie only vertical shafts are sunk. The most recent shafts are 16 ft. by 4 ft., and 12 ft. by 4 ft., and the shafts are divided into four and three compartments respectively. The sinking at the most important mines is done by machine drills.

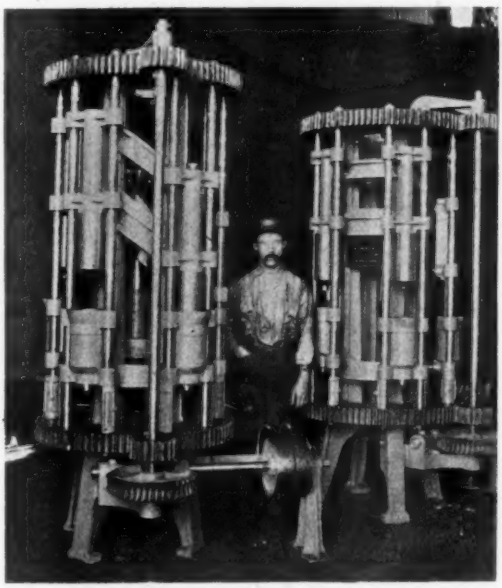
In the transportation part of mining, all kinds of machinery are in use. The primitive windlass and bucket still holds its own in outlying districts, and on what are termed "poor man's diggings," whilst on the large mines are to be found double-drum double-cylinder direct acting winding engines of modern type. Some of these plants have been made in the State, and some imported from Great Britain.

As a rule the prevalence of large bodies of water underground is not a trouble to the goldmining companies of Queensland, and there are not many pumping plants in connection with this industry. At many of the mines dams of concrete of some magnitude have been constructed to conserve water for mining purposes.

The milling of gold quartz ores has been carried on since 1867. It began at the Hector Mine, near Rockhampton, and since that time very great improvements have been made in the milling methods of the country, and some of the larger mines have quartz batteries, concentrators, and cyaniding plants of the most modern types.

The cyaniding process for the recovery of gold from the slimes or tailings from the battery process was introduced into Queensland in 1893. At first only empirical rules were followed in the process, but recently more technical skill is directed to this work, and better results are obtained by the application of chemical tests to the slimes treated. One of the common mistakes of former times was the emptying of the vat twenty-four hours before the cyanide solution had done its work, instead of which tests are now applied to determine when the cyanide has done its work.

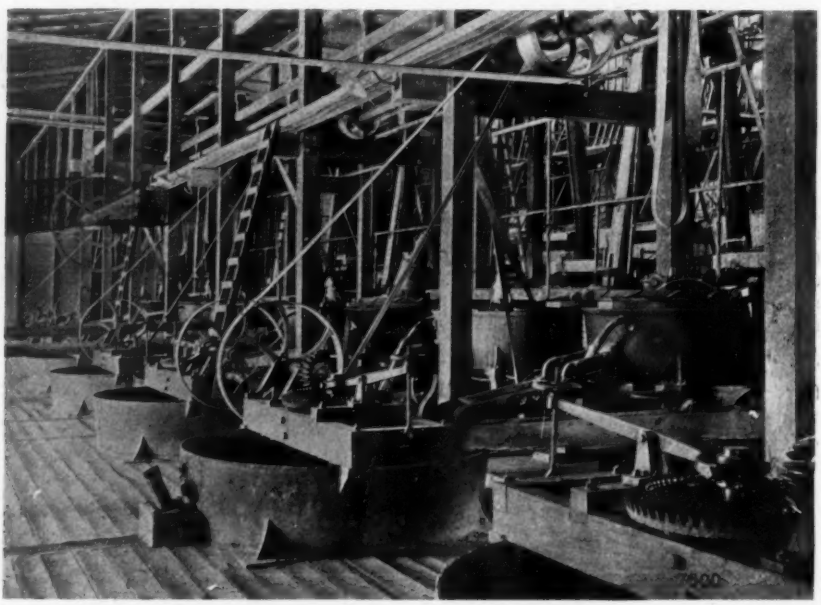
The illustration on page 37 is that of an improved winding engine made by Messrs. Thompson & Co., of Castlemaine, for Plant's Day Dawn Gold Mines, Ltd., Charters Towers. The engine, which has been specially designed to give economical results when winding from deep levels, possesses all the features of the engine made by the firm for the Broken Hill Block 10 Co., New South Wales. Instead of the ordinary high-pressure duplex cylinders, those of the twin tandem compound type, provided with special appliances for automatically controlling the steam distribution, have been employed. When working from deep levels, with parallel drums and the ropes unbalanced, it frequently occurs that the dead weight of rope down the shaft exceeds that of the net load of ore to be raised, thus necessitating great surplus power to start with, when compared with the normal work to be done. With ordinary duplex winding engines the cylinders require to be of the same size as the low-pressure cylinders of a twin tandem compound engine for the same starting load, but after being set in motion the power available is 100 per cent. more than is necessary to continue on winding. On account of this underload the friction absorbed by the engine represents a large proportion of the useful work done, and this class of engine, regardless of the class of valve gear applied to it, is incapable of being adjusted to suit the varying conditions of such work. The engine illustrated is arranged to automatically admit boiler steam to the low-pressure cylinders whenever starting, and by means of a patented device the boiler steam is cut off the low-pressure cylinders, and the engine starts working compound directly the load has been accelerated to a predetermined speed of winding. This same device again makes communication between the low-pressure cylinders and the boilers when the cage is nearing the surface so as to provide the maximum power, if necessary, for controlling the descending cage when nearing the bottom of the shaft, and landing the ascending one at the surface. The engine is of the twin tandem-compound direct-coupled vertical type, having two high-pressure cylinders



MEAT CANNING MACHINE, ROCKHAMPTON, QUEENSLAND.

15¼ in. in diameter, and two low-pressure cylinders 26½ in. in diameter, with a 42 in. stroke. The cranks are fixed at right angles to each other on the drum shaft, on which are mounted two loose parallel drums 9 ft. diameter, of specially heavy construction provided with claw clutches, and massive brake rings. The brake gear, which is operated by steam or compressed air, and locked in position hydraulically, is of the suspension post type, provided with a system of parallel motions, whereby the wear on the brake surfaces is uniform. The steam distribution valves are of the positively connected "Corliss" type, actuated by an original modification of the "Bremme" reversing valve gear, requiring but one eccentric, and having no sliding surfaces. Standing on brackets, cast in one with the main engine frames, are four steel columns towering to a height of 37 ft. from the ground, on which is fixed a steel superstructure and traveller in the form of a crane. By the aid of this crane the entire machine, with the exception of the bed plates and main frames, can be erected or dismantled.

The Mount Morgan Gold Mine.—The largest work in progress in Queensland at the present time is the erection of the new copper smelters at the Mount Morgan Gold Mine. The mine is one of the largest in the world, and is situated on the Dee River, about twenty-six miles inland from the port of Rockhampton.



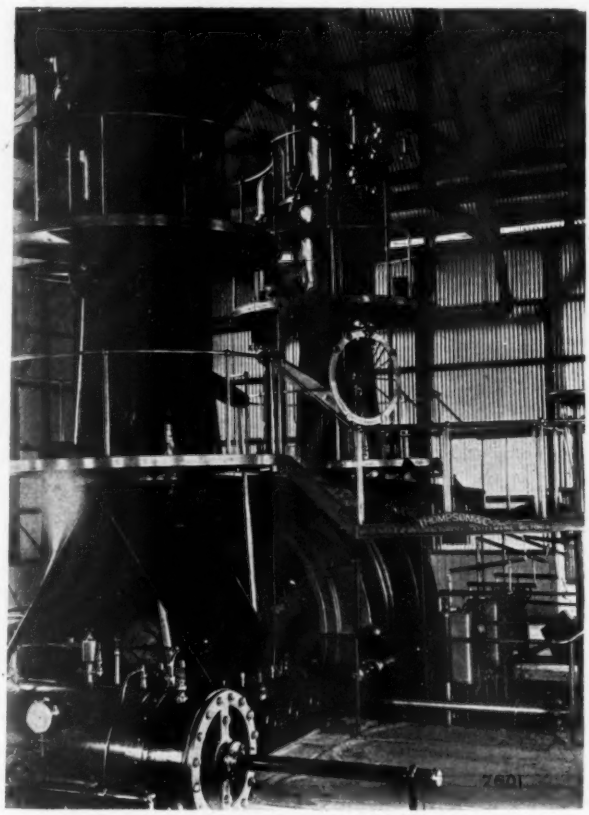
BATTERY AT THE "BRILLIANT BLOCK" GOLD MINE, CHARTERS TOWERS, QUEENSLAND.

Some extensive prospecting has been carried out recently, by means of diamond drills. The result of these explorations has been the discovery—the most important of recent years—of large bodies of gold—copper ore. So important is this discovery considered to be, and so well ascertained, that on the

strength of it new works have been erected for the special treatment of this new ore. As a great number of different plants have been erected in these works, comprising many kinds of machinery, a brief description of the different items of the various installations will be of interest.

The treatment of these recently-found copper ores is carried out under two sections. The first is the smelting. Here the raw ores are concentrated up to a matte containing about 50 per cent. of copper. The second is the conversion of this matte to blister copper of about 98 per cent. purity by the Bessemer process.

The blast furnaces are three in number and of large modern water-jacketed type. The whole of the ironwork was manufactured in the Commonwealth, much of it in Rockhampton by Messrs. Bruce and Reeves, Burns and Twigg, and Swilliams. Each furnace is designed to be capable of smelting 5,000 tons of ore per month, and it is proposed to run two furnaces concurrently, keeping the third in reserve in case of breakdown. So this new plant has approximately the same capacity as each of the big gold plants at the Mundic and West works.



VERTICAL WINDING ENGINE AT THE "DAY DAWN" MINE, CHARTERS TOWERS, QUEENSLAND.

The blast is delivered into the fusion zone of each furnace at a height of 6 ft. above the tapping floor by twenty tuyeres, which take their air from a bustle pipe surrounding the furnace. This pipe is combined with a vaporiser attachment, from which is circulated the water through the water jackets composing the walls of the furnace. The object of the vaporiser is to maintain a high and constant temperature in the water jackets and to minimise the amount of water needed for circulation.

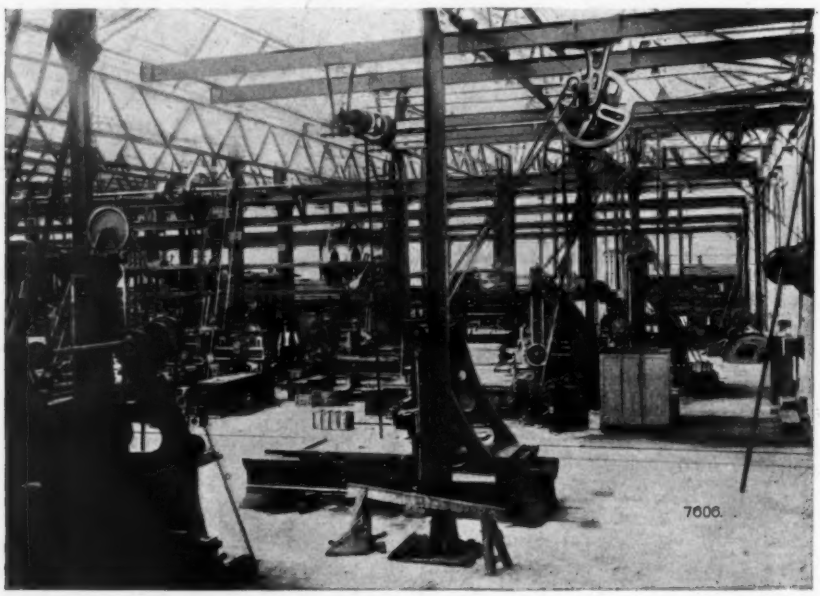
The blast for the furnaces is supplied by five large two-impeller blowers of the "Root" type. The blowers are independent, and any blower can be made to discharge its air into either furnace, and each is driven by its own electric motor of 100 horse-power.

The circulation of the jacket water from the blast furnaces is arranged for

by the installation of two electrically-driven contrifugal pumps, located about 30 ft. below the dump level at the foot of the gold plant. The water is pumped to a cooling tower whence it gravitates to the vaporisers to pass again through the jackets and be circulated again. Each pump is driven by a 15 h.-p. motor, and is capable of delivering 10,000 gallons per hour.

is, at the end of the process, of about 98 per cent. purity, contains also the gold that was in the ore. In this process, as in the others, electric power is used for turning over the furnace vessels, and carrying the ladles from the furnaces.

Wool-scouring Plant.—Wool-scouring machines are used in the western district. A typical machine of this kind has been made by Messrs. Burns and



MACHINE SHOP, STATE RAILWAY WORKS, QUEENSLAND.

The matte from the blast furnaces, containing about 50 per cent. of copper, while still liquid, is conveyed to the reheating furnace in the convertor house. This furnace is of the reverberatory type.

The final process is that of conversion to blister copper. This consists in blowing of air through a molten bath of matte in a cylindrical vessel of boiler plate, with a siliceous lining 2 ft. thick inside. This operation oxidises the sulphur and iron which make up half the weight of the matte. The copper, which

Twigg for Messrs. M'Laughlin & Co., of Barcaldine.

The plant consists of long scouring troughs of wooden construction, in which work a series of iron rakes which move the wool along the troughs. Between the two troughs are porcupine lifts, to raise the wool on to rollers, where the water is wrung out. The wool passes from the second washing trough into a hot-air drying chamber, from which it emerges ready for the baling machine.

Electrical Engineering.—Considerable progress has been made in Queensland,

in recent years in this department of engineering. Its first introduction was in connection with the lighting of towns, but not much advancement has been made in that direction. In some manufactories where steam power is already installed, electric lighting is used.

Electric power plants of considerable magnitude have, however, been installed in connection with the tramways at Brisbane, the Mount Morgan Gold Mine, and the State railway workshops at Ipswich.

Electric Tramways at Brisbane.—These tramways were laid down a few years ago by a company, and have been worked very successfully. The recent additions to the engines are of the cross-compound condensing vertical type. The steam pressure is 155 lbs. per sq. in., and this engine is capable of developing 800 h.-p. The makers are McIntosh, Seymour & Co., of Auburn, U.S.A. The boilers are Babcock and Wilcox type, six each of 212 h.-p., and two each of 230 h.-p.

The electric current for lighting Roma Street railway station is generated at the tramway power house by an automatic compound engine of 100 h.-p.

The lines installed in the street are 84 lbs. tram rails, 30 ft. lengths, 6 to 6½ in. deep The sleepers are of local ironbark hardwood and red gum wood, the timbers being split and seats dressed on which to bed the rails. The overhead system of working is adopted, with imported iron poles 6 ft. in the ground, with 2 ft. square concrete foundations. Outside the municipality, the poles are of hardwood timbers 18 ft. out of the ground. The gauge adopted is 4 ft. 8½ in. The fish plates, rails, bolts and all ironwork were imported.

In the power house of the Mount Morgan Mine three new 400 kilowatt Parsons-Boveri turbo-generators, equal to about 530 h.-p. each, are provided. The old capacity was only 200 kilowatt, so that the increase is equal to six times more. A new surface condenser, with three-throw Edwards's air pump and centrifugal circulating pump, all motor driven, and supplied by the Brush Electrical Engineering Co. of England, has also been installed. Another air compressor, which practically doubles the present plant, is to be added. It is of the Reidler type, of 3,000 cubic ft. capacity, fitted with compound steam cylinders of 19 in. and 33 in. diameter by 4 ft. stroke, with a reheater between the cylinders.

All the current which is required at a different pressure—for example, for lighting the company's houses and for arc lighting—will be generated by motor generators driven from the main circuit, in place of the old method by small engines through belts and countershaft.

WINDMILL PUMP BY THE TOOWOOMBA FOUNDRY CO., QUEENSLAND. 10 FT. SIZE ON A 20 FT. TOWER. TROUGHING IN FOREGROUND.

The space formerly occupied by three small steam engines of about 200 aggregate h.-p., is sufficient for the three new turbo-generators of 1,600 h.-p., together with the necessary condensing plant for the latter, or eight times the power in the same space. The present steam dynamos of 100 kilowatt each will be held in reserve for special purposes.

The winding engine and controlling device at the mouth of the inclined shaft are probably the finest pieces of machinery in the Commonwealth of Australia. The electric portion consists of two 200 h.-p. motors, geared to the winding drums. The electric parts are from the British Westinghouse Co., and the non-electric parts are of Queensland manufacture. Drums, gearing, indicators, and other items are specially designed for strength and safety. The brakes are of the post type, and operated pneumatically. The master-controller is so arranged that if anything happened to the operator whilst on duty, and he released the lever of the controller, it would simply fly back to the central position, thus cutting out the current and applying the brakes instantaneously.

In connection with these alterations a complete railway system has been installed throughout the works, connected to the State railway, which is carried up to the mine.

The power house of the State railway workshops at Ipswich is divided into two rooms, 112 ft. by 38 ft. and 112 ft. by 45 ft., the engine room and boiler house respectively. The engine room contains three generating units consisting of 200 kilowatt, 220 volts, Westinghouse 7,500 alternations, two-phase generators, each directly connected to a Westinghouse compound engine. From this plant power is supplied to fourteen different shops.

All the electrically driven machines are operated from motors, of which there are 161 installed in the shops, aggregating 1,200 h.-p. They range in size from 1 to 75 h.-p. They are of the polyphase type, designated as type "c" induction by the Westinghouse Co. For variable speed work, such as cranes, hoists, lathes, &c., the motor is designed for a different speed curve, and supplied with suitable regulating devices.

The cranes, eleven in number, are each operated by three motors, one each for hoisting, cross-traversing, and travelling, controlled by levers located in a cage suspended from the crane, and permit of all three motions at the one time.

Boiler Construction. A new feature.—A new departure in boiler installation has been made at Rockhampton, in the form of a combination of a Cornish and a multitubular boiler, placed in tandem. The Cornish boiler is placed at the front with its fire box, the multitubular is placed at the back, and a 4 ft. combustion chamber of brickwork is built between the boilers. The work has been carried out by Messrs. Burns and Twigg, from the design of Mr. John Lund. An economiser is also added to the combination, and the test shows the efficiency to be 87 per cent. It may be mentioned that the test of this boiler was carried out with coal from the Wallaroo mine, near Rockhampton. The coal showed a rather remarkable evaporative power, namely, 12·83 lbs. of water evaporated from and at 212° Fahr. per lb. of dry coal.

Windmill Pumps.—The manufacture of Windmill pumps forms no small portion of the works of private enterprise carried on in this part of Australia. It may be mentioned that along the coast of Queensland, from Brisbane in the south to Cooktown in the north-east, there is a stretch of coastal lands about 1,000 miles in length, by varying widths. Much of this country consists of the richest alluvial and volcanic soils. This land is being gradually brought under cultivation with the aid of irrigation. Pumping plants of various kinds are in course of erection. In most cases windmill pumps are being preferred, and several engineering firms are in full swing making these pumping machines.

An illustration is given of a good type of colonial manufacture of mill of small

capacity by the Toowoomba Foundry Co. of Toowoomba. One of the essential requirements of machinery in Australia is, simplicity in its parts, accessibility, and capability of standing rough usage. The great desirability of these points is self-evident, when it is considered that machinery, in most cases, has to work in remote localities, without much attention, and often many hundred miles by rail and carrier from the nearest foundry. The gearing, rods, sails and other parts of these machines are specially made by various local makers to suit these requirements.

Steam Machinery, General.—The principal mechanical engineering firms of the State have been able for many years past, to undertake the manufacture of steam power plants of moderate dimensions, including boilers of various types, small marine engines and boilers, horizontal engines, and buoys for harbour lighting.

The writer is indebted for part information, used in composing this article, to the following, amongst others, namely:—The Hon. the Minister for Mines, Queensland; The Hon. E. E. T. Plant, Charters Towers; The Under-Secretary for Public Works, Queensland; The Hydraulic Engineer, Queensland; the *Morning Bulletin*, Rockhampton; Messrs. Burns and Twigg, Engineers, Rockhampton, and Messrs. Smith and Faulkner, Brisbane. The kindness of the above is thankfully acknowledged.

Engineering in New Zealand.

By H. A. McGREGOR (Inspector of Machinery, New Zealand Government).

In speaking of the general progress of engineering in New Zealand, it has no doubt been practised, in an elementary degree, from the first settlement, viz., in the construction of country roads and bridges, advancing with the more elaborate works of main roads, railways, and mining. In all of these, owing to the mountainous character of a considerable portion of the country through which some of the works have been carried, engineering skill of a high order has been exercised in surmounting the various obstacles met with.

In connection with the harbours of the colony, some of the more exposed have had the attention of engineers of world-wide reputation in the designs of their breakwaters and training walls. In the more sheltered harbours, berthing accommodation, appliances for handling cargo, graving dock, &c., are the more important engineering works.

Mining in all its various methods has also provided a large field for engineering enterprise.

In tracing the progress of mechanical engineering in New Zealand, the earliest practical work of this nature was in the manufacture of small flour mills in connection with the Church missions. They were constructed almost entirely of wood by the natives, under the direction of the missionaries.

Soon after the settlement of the colony the latent engineering talent of the colonist began to assert itself in the erection of saw mills and flour mills, water being the motive power. A little later (but long before there were proper appliances for such work) steam engines of considerable power were constructed, and continued to do duty for many years.

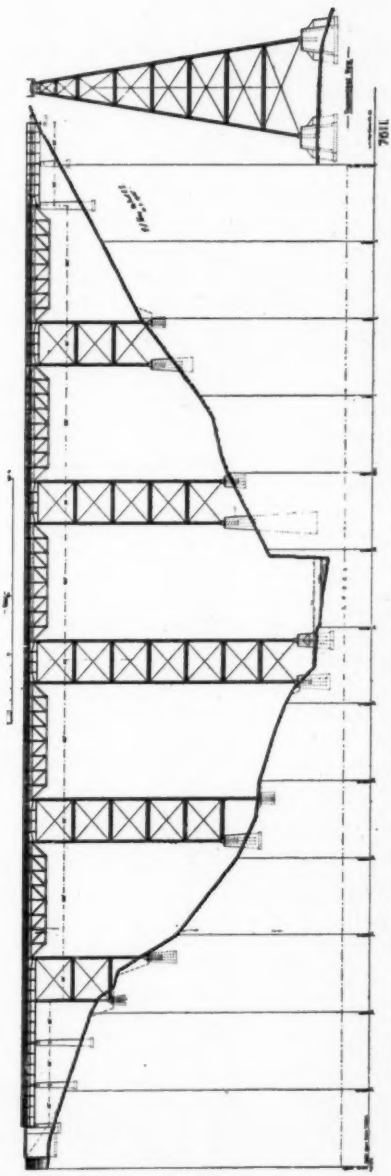
The discovery of gold in various parts of the colony between 1852 and 1861 marked a new era in the industries of the country, changing as it did from the quiet of an almost rural population to the rush and bustle of a mining one. A considerable impetus was at this time given to mechanical engineering, many of the larger present-day works dating their origin back to the early days of the gold-fields. Up to this period the owners of machinery depended almost entirely on the country smith and wheelwright. In a few years, however, the engineering works were equal to the principal wants of the various industries that had sprung up. About 1866 a revival of the Hemp (*Phormium tenax*) industry caused it to be recognised as a business that would require considerable attention from mechanical engineers. Mills were soon in operation in all parts of the country where the Phormium plant flourished, necessitating the enlargement of existing machine shops and the erection of new ones to meet the constant demand for flax-mill machinery.

The colony had by this time acquired a considerable fleet of small steamers and sailing craft, whose annual repairs had materially assisted in the development of, and warranted a still further increase of machine tools in the larger engineering establishments suitable for marine engine and boiler work. The erection of saw mills on a much larger scale than heretofore was also about this time found necessary to meet the growing requirements of the colony. In keeping pace with the above and various other demands mechanical engineering had, as far back as 1875, made such a considerable advance that some of the works were in a position to build small locomotives for the Government. Goliath cranes for breakwater construction had also been built, large flour mills

erected, winding, pumping and quartz crushing machinery constructed. A little had also been done in the iron and steel ship building, but in this branch of the iron trade the pace has been slow—only some twenty coasting steamers, the largest about 300 tons gross, having been constructed up to date. The Auckland district of the North Island, with its splendid timber and other facilities for ship building, has from an early date in the history of the colony taken the lead in this industry, many very fine sailing vessels and a number of small steamers have been, and continue to be, turned out from these Northern ship yards. Of late years oil engines have been fitted in quite a number of sailing craft—yachts and launches—in all of which mechanical engineering has played some part.

The works now established in the principal ports of the colony are replete with machinery which has enabled them for many years back to execute all manner of repairs to the fleet of New Zealand vessels (now aggregating over 160,000 tons), such as lengthening or carrying out repairs to the hulls, repairs to and renewals of engines, boilers, &c. The ocean steamers now visiting these waters can also have the very most of their repairs carried out with despatch. At least two of the larger establishments have added to their works up-to-date machine tools for the manufacture of locomotives, a number of which have already been built for the Government, and are giving every satisfaction to the railway department. The engineering works and iron foundries of the colony now number over a hundred (exclusive of Government railway shops). There are about another hundred works (branches of the iron trade) where a considerable amount of mechanical engineering is carried on. Altogether the facilities for handling work are far in advance of what the orders at present coming forward would warrant.

Railways.—Referring to the more important public works of the colony, the railways take first place. The mileage

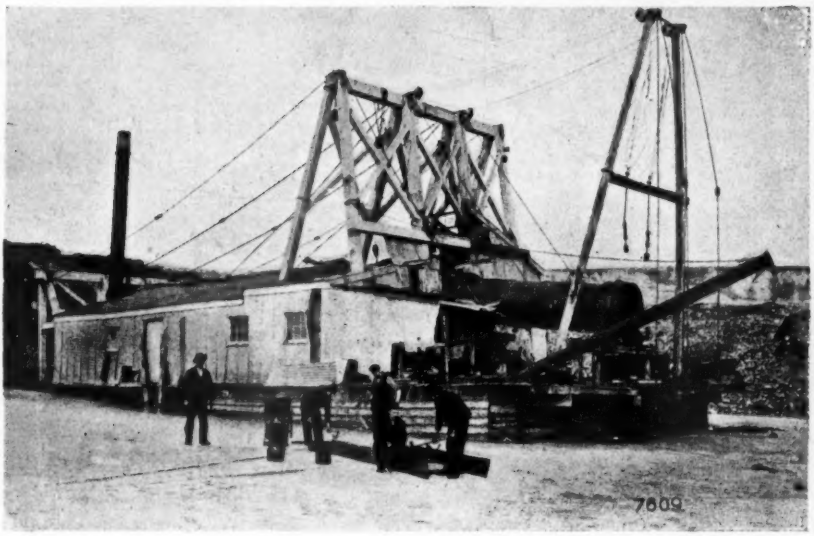


NORTH ISLAND MAIN TRUNK RAILWAY. MAKATOLE VIADUCT OF FIVE SPANS OF 36 FT., FIVE SPANS OF 100 FT., AND FIVE PIERS OF 36 FT. HEIGHT FROM CREEK BED TO RAIL LEVEL, 260 FT.

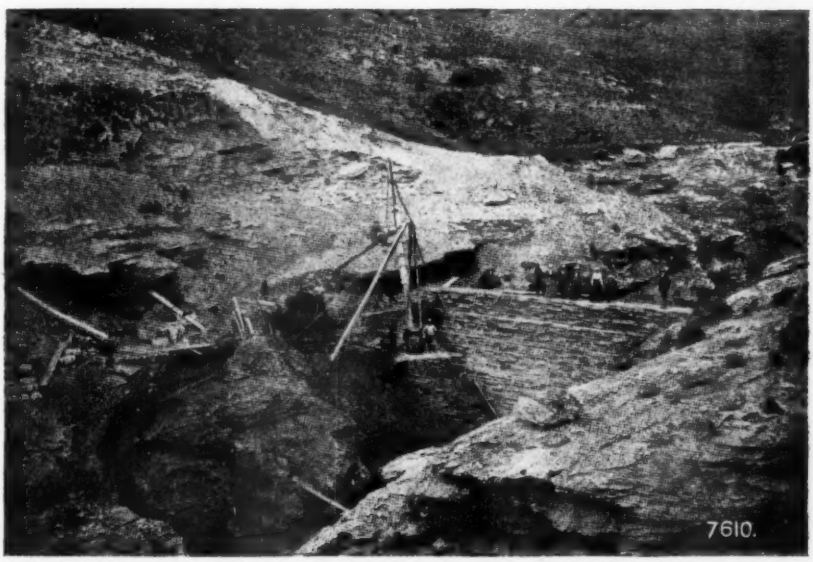
constructed under the Public Works Act of 1871 has, with the addition of some short lengths of private lines bought up by the Government, now reached a length of 2,374 miles open for traffic, and about 188 are under construction. Many obstacles of considerable magnitude have been encountered and successfully overcome as the work progressed, and looking ahead there are still a number to contend with before the trunk lines are completed. The revenue for the year ended March, 1905, was £716,331, which is equal to a return of 3·30 per cent. on the capital invested in open and unopened lines. The train miles run during the year were 6,107,079. The net earnings per average mile open was £304. The net earnings per train mile 28·04*d*. The railway workshops have grown with the railways. Private firms formerly contracted for a considerable amount of the construction work in the shape of points, crossings, &c., &c., which are now made in the workshops of the Department, in at least five of which appliances for the repairs and construction of new rolling stock is quite up-to-date. The larger of the works have already constructed several locomotives during the ten years ended 31st March, 1905, in the early part of which period the workshops were not so well equipped as at present, and considering the amount of work performed by the Department in the erection of new stations, bridges, &c., outside what might be called the legitimate work of repairing and manufacturing rolling-stock, the record for the period is a very good one. It is as follows: Locomotives built new, 39; converted and re-built, 25; erected, 57. Locomotive boilers built new, 115. Crane boilers new, 19; Carriages built new, 319; converted and re-built, 96; erected, 63. Brake vans built new, 115; converted and re-built, 31. Waggons built new, 4,250; converted and re-built, 1,032; erected, 1,000. New points and crossings constructed, 1,442 sets. Cranes built new, 2; erected, 8. And, in addition, there were under construction on the 31st March, 1905, but incomplete at that date, 8 locomotives, 71 carriages, 13 brake vans, 132 bogie waggons, and 392 four-wheeled waggons.

The department with a view of keeping pace with the increasing business and further augmenting the stock, had a comprehensive programme prepared for rolling-stock to be built in the railway workshops for the year ending March, 1906, consisting of 60 carriages, with seating accommodation for 3,240 passengers; 290 waggons, and 6 travelling cranes, the whole of which are now practically finished. The Westinghouse brake, with which it was decided to equip the rolling stock in 1900 is also practically completed. It is found to be highly efficient and an eminently satisfactory adjunct to the railway system. Its utility is particularly noticeable in the handling of fast passenger and heavy goods trains. Pintsch's gas system has also been fitted to the passenger cars, brake vans and postal vans. Four large steel viaducts have been erected, replacing those constructed of wood twenty-five years ago and not intended for the present weight of rolling stock or speed of trains. 70-lb. rails are now the standard for the main lines of the Colony, 228 miles being re-laid with that weight of rail last year.

With the object of increasing the durability of the New Zealand timber used for sleepers, two creosoting plants have been erected and a large number of sleepers treated. The increasing traffic on the railways is more particularly felt on such sections of the road as the Rimutaka Incline, worked on the Fell system. On this particular part of the line the Department have placed three of their own make of goods engines, converted to negotiate the grade without the assistance of the middle or grip rail, except in connection with the Westinghouse brake. The engines have proved an unqualified success, and arrangements have been made to build all future engines required for the incline in their own workshops. The new locomotives will be compound double-ended tank engines. It has also been decided to build a number of powerful four-cylinder



GOLDEN BEACH DREDGE, ALEXANDRA. REPAIRING ON ICE.

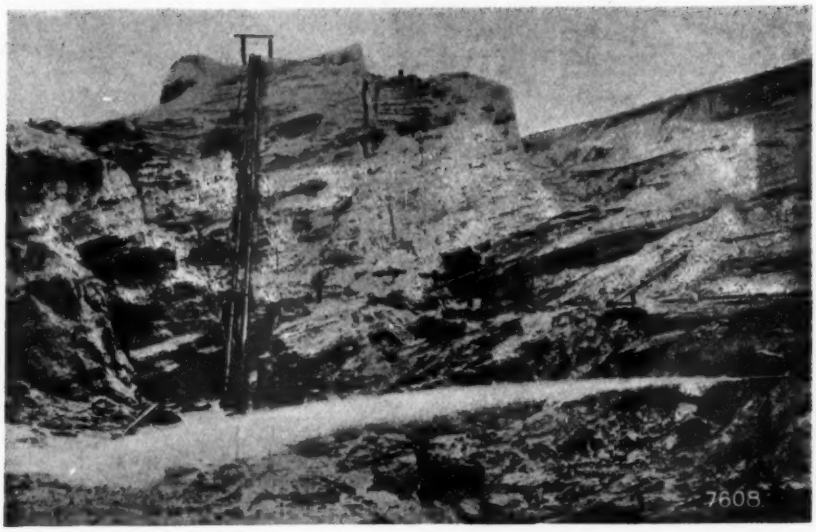


DAM AT SPEARGRASS CREEK. OUTER FACE OF WALL.

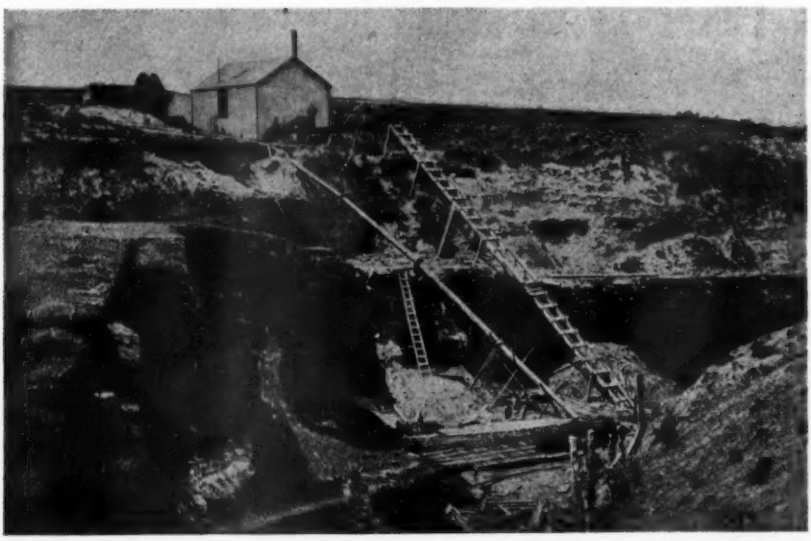
balanced compound engines for passenger and goods trains, having greater tractive power than any of the existing types. Also a number of heavy type goods engines to be used on the steep graded portions of the North Island Main Trunk Line. A few years more should see the whole of the Trunk lines completed. The illustration of the Makatote Viaduct on the North Island Main Trunk Line will give some idea of the class of work in connection with this line.

Harbours. — Other important public works of the Colony are its harbours, which are, for the most part, vested in Harbour Boards. The extensive coast line of New Zealand, of some 4,330 miles, although endowed by nature with some of the finest harbours in the world, has yet many long stretches of sea-board almost entirely without shelter, and large sums have been expended in the construction of breakwaters with the object of providing harbours of refuge in such exposed parts. In connection with the bar harbours, training walls and breakwaters have also been built with the object of deepening the channels by inducing a strong scour. Extensive dredging operations have, and are still being carried out with the same object, in some of the navigable rivers. In the more sheltered and larger ports of the Colony attention to the accommodation for berthing the large ocean steamers and despatch in handling cargo, has been the principal immediate object of the Harbour Boards, who in some of the ports have provided extensive and substantial wharves, replete with up-to-date cranes capable of handling lifts up to 40 tons, as also commodious buildings for the temporary storage of outward or inward cargo. Extensive bonded stores are also provided. In three of the principal ports large graving docks and patent slips have been constructed, and in connection with two of the graving docks there are extensive engineering shops with all the necessary machine tools for the manufacture of the various parts of marine engines that might require to be re-placed. Forges for heavy shafting, &c., as also powerful shear-legs have been provided.

Mining.—Gold mining as one of the principal industries of the Colony may be referred to by first mentioning that the total value of gold mined in New Zealand up to date is £65,136,648, and for the year ended March, 1905, was £1,987,501. In the early years of the gold fields the gold was obtained from alluvial diggings, but at the present time the greater quantity is taken from gold-bearing quartz. The chief centres of this branch of mining being the Chinemuri, Thames, and Coromandel districts in the North Island, and the Inangahua country in the Middle Island. In the northern fields more especially, powerful pumping, winding and crushing machinery, together with the most up-to-date gold saving appliances have been erected. Taking the Waihi Gold Mining Co. as an illustration, with their output for the year 1904 of 259,978 tons of quartz, from which bullion to the value of £673,101 was obtained, and dividends to the value of £297,544 were paid, it will be seen that gold mining is at times a profitable investment. In the Middle Island, Inangahua country, quartz mining is also successfully carried on, gold to the value of £200,000 having been won during the year ended March, 1906, by the registered companies of that district. Water is much used in this locality as a power for winding, pumping and crushing, and much ingenuity is displayed in the numerous aerial tram lines for the conveyance of fuel for the engines and quartz to the crushing machines. Hydraulic and alluvial mining is also carried on in several of the gold fields of the middle island, principally in sluicing, a method by which the auriferous earths are disintegrated by powerful jets of water, brought on to the gold-bearing country by miles of water races and steel fluming. Dredging machinery is also much in use in various parts of the Colony, chiefly in the south of the Middle Island, where the alluvial deposit in the beds of the rivers is lifted and subjected to a washing process by which the gold is saved. Steam is the principal motive



SCANDINAVIAN GOLD-MINING COMPANY S CLAIM, T. BATHAN'S, OTAGO. SLUICING AND ELEVATING.



NIGHTCAPS COLLIERY. VIEW AT OUTCROP, WITH VENTILATING FAN ON TERRACE

power used, but in one or two cases where water under pressure is available, it has been utilised through the medium of the electric motor. An illustration is given of a gold dredge on the Clutha River, Otago, also of a dam at Speargrass Creek, showing the face of outer wall. Also a view of a hydraulic sluicing and elevating claim. The material, after being sluiced down, is in this case elevated by a jet of water to a higher level in order to get a fall for the tail race.

Coal.—Coal, one of the principal products of the Colony, may be briefly mentioned to show in some measure its indebtedness to mechanical engineering in the various appliances for the rapid and cheap production of that valuable commodity. Looking back 30 years at the then output of 100,000 tons, a very substantial advance is shown in the present annual production of 1,537,838 tons. The production is now almost equal to the Colony's consumption, for although there is still a considerable quantity imported, yet there is, for a young country like this, a very respectable export trade in the best steam coal, principally to the naval stations of Australia and China for vessels of the Royal Navy. New fields are constantly being developed, and in a short time importing should cease, while the export trade might increase by the addition of Anthracite coal. Almost the whole of the machinery of the mines is now manufactured in the Colony, only such specialities as coal cutting and rock-drilling machines being imported. The latter machines, as also a considerable amount of the underground hauling and pumping machinery, is now actuated by electricity or compressed air, preferably the latter, as it materially assists in the ventilation of the mines. On page 47 is a view of the Nightcaps Colliery, Southland, working a 36 ft. seam of brown coal, annual output 43,000 tons.

The Progress and Present Position of Engineering in New South Wales.

By J. W. ROBERTS, B.E., Sydney University.

The Work of the Pioneers.—One hundred and thirty-six years have elapsed since Captain James Cook in a 320 ton craft, which subsequently carried him round the world, sailing in these southern seas in search of a new continent succeeded in his quest by landing on the shores of Botany Bay. Eighteen years later the Colony, now the State of New South Wales, was founded by Governor Phillip; the white man shouldered his new burden and, incidentally, the black man, being no longer required in the economic scheme, began to slowly crumble through decay into final extinction.

The necessity for a pure and ample water supply fixed definitely the site of the original settlement on the spacious margin of Port Jackson, and so of the City of Sydney. Early records speak admiringly of the picturesque beauty of the Tank Stream which kept the growing community supplied till about 1827, when it became too highly contaminated for use. By this time connection to the Hyde Park reservoir had been made from the Lachlan Swamps, the present Centennial Park, by means of a tunnel known as Busby's Bore, after the constructing engineer. In 1858 it was necessary to go still further afield, and pumping plant was put in by the city council at the Botany Swamps. The water discharged into the Crown Street reservoir, from which it was still further pumped into service reservoirs commanding the higher levels of the metropolitan area. This system of supply served for thirty years and was then replaced by the existing system, which taps the Nepean, Cataract and Cordeaux rivers.

In 1815 a steam engine, the first in Australia, was imported for use in a flour mill.

The year 1823 witnessed the inception of the first Australian foundry, at first carried on by James Bland but in 1842 purchased by Peter Nichol Russel, and another foundry was established in 1833 by Richard Dawson which carried on operations for nearly forty years.

The first steamer built in the Colony was equipped with imported machinery, and started running to Parramatta in 1831, about the time that the first steamer arrived from England, a vessel of 153 tons register and 50 horse power.

The pioneer marine engineer in this Colony was John Struth, who established works on Darling Harbour in 1840 and did a most extensive business in shipping construction and repairs and marine engines. The North Shore Steam Ferry Service owed its origin to his enterprise, both boats and machinery being locally manufactured. Pioneer civil engineering consisted in laying out the city streets, designing and constructing the important public buildings, looking after the water supply, making general surveys inland and along the coast and opening up and improving lines of communication between the various settlements.

The greatest achievement and one fraught with the deepest significance for the welfare of the growing Colony, was the exploration, survey and final construction under almost insurmountable difficulties of the main road to the West over the Blue Mountains, completed to Bathurst in 1815.

In 1841 the City of Sydney was lit by gas supplied by the Australian Gas Light Co., which still holds the monopoly of this form of illumination within the Metropolitan area, though it has been recently dispossessed of street lighting in the City proper by the Council's own electric supply.

Coal was first discovered in New South Wales in 1797 at Mount Keira and near the Hunter River, both important coal mining centres at the present day. The Government from 1797 to 1829 possessed and managed a colliery of their own at Newcastle, and supplied vessels at the rate of 10s. per ton.

This valuable mineral covers an enormous field in this Colony. It is estimated that the quantity available for working is not less than 115,000,000,000 tons.

After sixty years of settlement we find the following manufacturing establishments

within the Colony :—65 steam flour mills, 26 windmills, 43 water mills, 38 horse mills, 13 iron and brass foundries, 1 smelting works, 1 gas works, 18 soap and candle factories, 2 sugar refineries, and 98 other factories. For the most part, however, the settlers had to labour under discouraging difficulties. Periods of drought were frequent, and the crops were continually failing. In the earlier days labour was scarce and wages correspondingly high, while the population increased very slowly. Assisted immigration was resorted to and caused a temporary wave of prosperity. Then came the reaction, prices and wages fell, a tide of emigration set out, chiefly for California, insolvency became rampant, and an atmosphere of intense gloom pervaded the Colony. Never before had such utter stagnation and impending ruin threatened its welfare, and never since. At this critical juncture occurred an epoch-marking event in the annals of Australia, destined thereafter to exercise a profound influence over its future industrial and commercial progress.

Gold and the Mining Industry.—The presence of gold in small quantities had been known in certain official quarters for a very considerable length of time, but the social organisation of the settlement in its early days made it advisable to withhold the information from the public generally. In 1851, Mr. E. A. Hargraves, full of newly-acquired experience from California, found gold of a payable character at Lewis Ponds near Bathurst, and also at Summer Hill in the Wellington district. He made his report to the Government, and in a few weeks there were over a thousand prospectors in the field, constituting the first of many famous gold rushes in Australia.

An almost simultaneous discovery of rich fields was made in Victoria, and a great influx of the sturdy youth of the world began to set in towards the land of the royal mineral. Many expert miners were among these, and their experience led to still further discoveries of alluvial beds over various portions of New South Wales, including Tumut, Adelong, Braidwood, Temora, the New England district, the county of Gloucester, &c.

While the alluvial deposits were plentiful and easy of access, quartz mining remained in abeyance on account of the great cost of machinery and appliances and the necessity for organised capital and labour. It now, however, represents the bulk of gold mining carried on in this country, the principal fields being at Cobar, Wyalong, and Hillgrove.

The activity engendered by the search for gold led to the discovery of many other valuable minerals and the establishment of highly important works requiring extensive and varied machinery and appliances for their due equipment. The steady advance made in steam engine design and economy and the triumphant progress of electrical science and its practical application to all kinds of mechanical requirements were vital factors in mining development.

The improved prices that have ruled recently for silver, lead, copper, and tin have stimulated production very largely and lead to still further improvements in mining plant generally, chiefly in the way of electrical installations for lighting, hauling, and driving all the various machinery.

The most noted group of mines in New South Wales is situated at Broken Hill, where plant equal to any of its kind in the world is to be found. Here are mined silver, lead, zinc, and gold from the rich and extensive ores yielded by the field. The recovery of zinc from the ore and tailings represents the latest metallurgical improvement, while the manufacture of salt cake from the sulphuric acid yields a valuable by-product. During last year, three 160 kilowatt, 3-phase, "Brown-Boveri-Parsons" steam turbine alternators were installed at Block 10, giving a current at 500 volts with periodicity of 50 cycles Four Babcock and Wilcox boilers, fitted with superheaters and chain grate stokers, supply steam at 160 lbs. pressure. The condenser pumps are electrically driven. The current is carried on overhead conductors to the mill half a mile distant, where twenty motors, ranging from one to thirty h.-p., are in operation for driving ball mills, crushing rolls, vanners jigs, bucket elevators, centrifugal pumps, &c. In addition, the power is conveyed to Harvey's shaft, driving two 40 h.-p. motors for rock breakers and a smaller motor for an ærial tramway. The Australian Metal Co. carried out the installation. During the present year Messrs. Noyse Bros. will install at the Proprietary Mine a "Westinghouse" pumping plant, including polyphase generators, switchboard, and motors.

Next to gold and silver the most valuable asset to the State is copper. The great bulk of this is from the Cobar mines, which also yield the largest amount of gold. The depression resulting from the hitherto low price of the metal passed off in view of the permanent improvement in that respect, brought about chiefly by the great demand for copper in electrical undertakings.

Next to the silver-lead yield the production of coal has been the most valuable

contribution to the State wealth for the year, the quantity raised being 6,632,138 tons. The extent of the field has already been noted, but a good deal of interest centres round the shaft of the Sydney Harbour Collieries Co., the deepest in Australia, which taps an immense field underlying Port Jackson, and forming a connecting link between the great coal areas of the North and South. The presence and probable depth of this field had long ago been predicted by several geological experts, and confirmed by boring operations with a diamond drill at Cremorne Point, which reached a depth of 3,095 ft. The presence of a volcanic dyke necessitated the putting down of a second bore 5½ in. diameter about half a mile away, which tapped an excellent coal seam 10 ft. 3 in. in thickness, at a depth of 2,917 ft. As public opinion was strongly against the spoliation of an attractive foreshore, the company transferred operations to Long Nose Point, Balmain, where two shafts have been sunk, one complete, 2,800 ft. deep the other about half-way, both 18 ft. diameter lined throughout with brickwork. Machinery of the most modern type suitable for deep mining has been installed, including a Walker's fan, 24 ft. diameter, 8 ft. wide, for the ventilation of the underground workings.

Since the 1896 Coal Mines Regulation Act, the ventilation of underground workings generally has received much attention, and patent fans of various makes, some as large as 34 ft. in diameter, have been added to the equipment in place of the old-time furnace.

In addition to the extensive electric installations that have been made, a very recent improvement in coal mining has been the introduction of the chain coal cutting machine, of which there are now a large number of different types successfully in operation, the motive power being compressed air or electricity, chiefly the latter. At Newcastle, where most of the coal exported or used for over-sea purposes is shipped, the handling is done by eighteen powerful hydraulic cranes installed by the Government which account for over two million tons per annum.

About 160,000 tons of coke, natural and artificial, are used annually, chiefly for ore reduction. Large smelting plants have been established at Dapto, Cockle Creek, and Woolwich, and copper reducing and refining plants at Lithgow and Newcastle; it having been found more economical to bring the ore to the fuel than to reverse the operation.

The following table is a summary of the progress made in mining operations during the last ten years:

Mineral.	Value won in 1895.	Value won in 1905.	Value of Plant and Machinery at end of 1904.
	£	£	£
Gold	1,315,929	1,165,013	913,370
Silver, lead and zinc	1,642,671	2,717,864	764,333
Copper	136,969	511,754	253,415
Tin...	87,937	173,806	46,793
Coal	1,095,327	2,003,461	898,000
All other minerals	134,747	446,042	53,525*
Total	4,413,580	7,017,940	2,929,436
		Conveyance plant ...	836,000
		Plant at smelting works	250,000
		Total	4,015,436

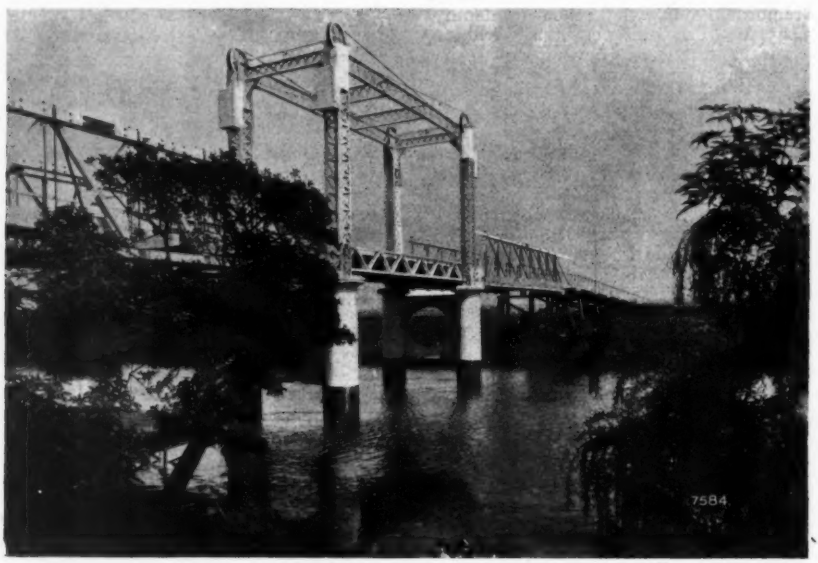
* Includes only metallic minerals.

The importance of the mining industry in its bearing on the general welfare of the State, can hardly be overestimated. The discovery of gold rescued the Colony from dire distress in its infant days, and ever since its great mineral wealth has been a source of strength and stability. The development of population, of manufactures, of the railway system and of inter-State and oversea shipping has been enormously encouraged by the systematic exploitation of this wealth. The industry has grown to its present dimensions through the persistent and strenuous application of human energy, skill and knowledge in the face of harrowing and continually recurring difficulties.

In addition to the troubles arising from natural causes, such as earth, fire or water, incidental to all mining, the manager is perennially haunted with the spectres of water famine, of disorganization through labour tactics, of a fall of prices in the world's market. Even a change in the Customs tariff affecting the price of machinery may mean the difference between profitable and unprofitable working.

The Manufacture of Iron.—In extraordinary contrast to the development of mining for the rarer metals enumerated above, and for coal, we find in the treatment of the native iron-ore deposits, not only in New South Wales, but throughout Australia, until quite recently, a condition of absolute stagnation. Yet these deposits are most extensively distributed in this State and in some localities are of great richness. On a minimum

estimate there are 53,000,000 tons of ore in sight capable of yielding nominally about 27,000,000 tons of metallic iron. First class coal fields are in the vicinity of all the important deposits, and there is an abundance of good limestone throughout the State. The ore occurs in the form of magnetite, brown hematite, limonite and bog iron ore. The railway system is in close proximity to the most valuable fields which are at Cadia, Carcoar, Cowra, and Queanbeyan. The total value of iron-ore raised to the end of



LIFT BRIDGE AT HINTON, PATERSON RIVER, N.S.W.

1904 was £114,301, and of the average annual output for the six years preceding, £8,490. The bulk of the mineral was chrome-iron, and was used almost entirely as a flux.

During that period the average value of the pig and manufactured iron and machinery imported annually into New South Wales was about £2,000,000, and into Australia about £4,500,000. The maufactured iron includes bar, rod, plate, sheet and scrap, rails, plain and barbed wire, galvanised iron and pipes. The apathy thus shown with regard to the establishment of blast furnaces, and local manufacture of iron and steel is not difficult to understand.

The chief reasons for such an attitude may be summarised thus:—(1) The necessity for a large preliminary expenditure of capital on plant, material, and buildings, and the long period that would elapse before any return could be expected; (2) uncertainty of the tariff both prior to and since the establishment of the Commonwealth due to the balance, for a great number of years, between the two chief political parties; (3) uncertainty as to labour conditions, due to the intrusion of labour, as the third party, into politics, and the increasing strength and aggressiveness of labour organisations; (4) the competition of such big producing centres as Great Britain, United States, Germany and Belgium, and the prospect of cheap surplus stock being suddenly dumped down on the local market; (5) the futility of export and consequent reliance upon the home market, which was comparatively small and but tardily expansive.

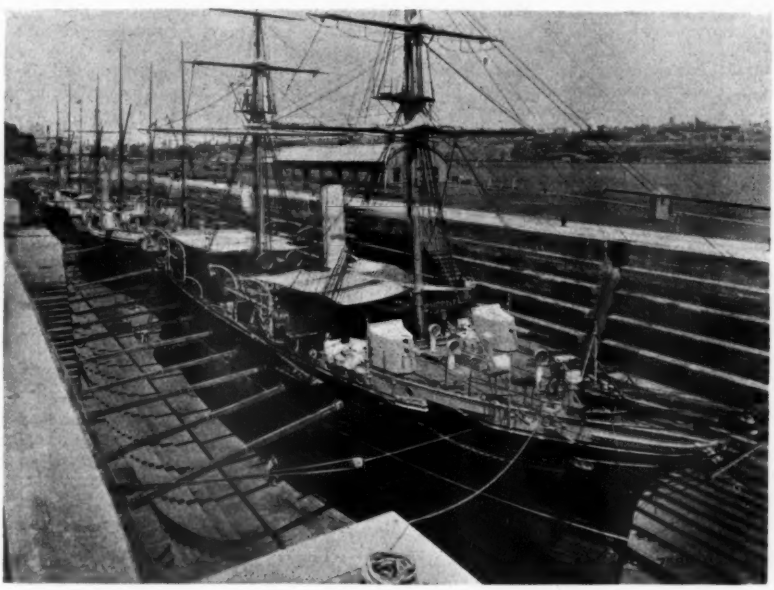
As a set-off the local manufacturer had the advantage of being on the spot, of saving freight, insurance and duty, and of being able to effect a considerable shortening of time in the supply of materials.

In March, 1905, the State government

decided on a bold move, and called for tenders for the establishment of works for the smelting of native ores and for the manufacture of steel and iron within the State. The ores and fluxes might be raised anywhere in the Australian Commonwealth, and 10 per cent. of the pig-iron used in the manufactured work might be imported. The whole of the pig-iron and rolled steel and ironwork required by the government of New South Wales for a period of seven years from a date to be fixed by the contractor, were to be manufactured and supplied at schedule rates, either direct or to any contractor carrying out work for the Government, the Railway Commissioners, or the Sydney Harbour Trust Commissioners. The contractor was allowed to delete from the schedule any items he was not prepared to deal with. Any bonus granted by the Federal Parliament, to encourage manufacture of materials included in the contract was to be deducted, to the extent to which it had accrued on materials supplied, from money due to the contractor. The schedule rates to be invariable during the period of the contract, with the exception of such as referred to the allowed proportion of imported pig.

The contractor was thus insured a minimum demand, and had the private requirements of this State and the public and private requirements of all the other States as an additional field in which to operate.

In spite of this encouragement only one tender was received, that of William Sandford, Ltd., of the Eskbank Iron and Steel Rolling Mills. About fifteen years ago at these works, which at present cover about 20 acres of ground, some experimental smelting was done with local ores, which, together with coal and limestone, are all in the immediate neighbourhood, and the result was highly successful. Some castings from the original pig are still on active service in the works. In the face of outside competition the youthful enterprise was abandoned and operations were confined to the rolling of light rails, bars, shapes and plates. At the present time the mills are capable of turning out flats up to 10 in. by 1 in., squares to $3\frac{1}{4}$ in., rounds to $4\frac{1}{4}$ in. diameter, channels to $5\frac{1}{2}$ in. by 2 in., iron



H.M.S. "TORCH," "RINGDOVE" AND "GOLDFINCH" IN SUTHERLAND DOCK, SYDNEY.

rails to 22 lbs. per yard, steel rails to 42 lbs. per yard, angles to 6 in. by 3½ in., and tees to 6 in. by 3 in., besides other special lines. The material is rolled from scrap and from imported blooms. About 6,000 tons per annum are turned out valued at £80,000. The total output to date is 115,609 tons valued at £1,073,960.

The works also possess two four-ton "Siemens-Martin" open-hearth steel furnaces, from which steel castings of great toughness up to 7 tons weight can be made.

In his tender, Mr. Sandford, availing himself of the privilege conceded in the contract conditions, agreed to supply the whole of the pig-iron, but only such other manufactured material as the mills were then capable of turning out. Should the pig-iron locally produced turn out a success, steel furnaces would be erected and the manufacture of steel from the pig-iron entered upon. The heavier rails and larger sections would then be rolled and come in under the clauses of the contract. The whole of the ores, fluxes and fuels would be raised in New South Wales. Mr. Sandford was asked to make a couple of amendments in his schedule rates which he agreed to, and his tender was then accepted and the contract signed.

The step thus taken is one of immense importance and interest to the engineering and manufacturing trades, and is destined, if successful, to influence industrial progress in the future to the extent that the discovery of gold influenced it in the past. It means the inauguration of the iron industry in Australia, which at present relies entirely on outside supplies. In 1904 Great Britain forwarded 1,400,000 tons, United States 400,000 tons, Germany 115,000 tons, and Belgium 100,000 tons of structural steel work. It has been estimated that to satisfy Australian requirements annually would take 1,400,000 tons of ore, 2,000,000 tons of coal, and 300,000 tons of flux. It would require 8,500 men to deal with this quantity of material, which again represents a population of, say, 34,000 dependent on the industry.

The Engineering Trades.—Although the manufacture of iron and steel and of the rolled material therefrom is in so backward a condition, the conversion of that material into finished commodities has been carried on with great enterprise. This comprises the manufacture of bridge and roof structures, steamers and dredges, rolling stock, conveyance plant, reservoirs, and the varied machinery and plant required in the numerous branches of the great industries of the State—mining, manufacturing, pastoral and agricultural.

Industry.	No. of Establishments and Value of Machinery.	No. of Hands and Amount of Wages.	Value of Goods Manufactured or Work done.	Horse-Power of Machinery.				
				Steam.	Gas.	Electricity.	Oil.	Turbine.
Engineering and Iron Trades ...	199 £417,917	4,867 £406,890	£1,119,644	5,528	386	65	29	—
Railway and Tramway Workshops	21 £244,246	3,668 £446,687	£42,152	882	—	797	—	—
Dock and Marine Engineering	29 £161,407	1,309 £170,736	£265,901	2,573	26	96	3	—
Other Metal Trades	77 £99,897	1,551 £112,910	£1,219,553	322	284	32	—	—
Smelting Works	41 £720,974	3,253 £379,659	£3,657,398	9,017	—	617	3	720
Totals	367 £1,644,441	14,648 £1,516,882	£6,304,558	18,322	696	1,607	35	720

The above table gives some idea of the scope and value of the metal trades generally up to the end of 1904, complete statistics for 1905 being not yet available. Under Engineering and Iron Trades are included the workshops under private management undertaking general engineering work, other than marine, iron foundries, and factories for galvanised ironwork and agricultural implements; the Railway and Tramway Workshops are, with few exceptions, the property of the State; while under Dock Engineering is included the Government docks and workshop at Cockatoo Island; other metal trades include brass and copper foundries, lead mills, factories for cutlery, tin and zinc works, stoves and ovens, wire workings, &c.

The total value of the goods manufactured, £6,304,558, which includes also repair work. State engineering establishments are limited,

at present, to the Fitzroy Dock and the locomotive workshops at Eveleigh.

The more important private firms carrying on engineering work in this State are the Mort's Dock and Engineering Co., Clyde Engineering Co., Wm. Sandford, Ltd. (Eskbank Iron and Steel Rolling Mills), Henry Vale & Sons, Ritchie Bros., G. & C. Hoskins, Poole and Steel, Gummow, Forrest & Co. (special lines in concrete-steel), and the Meadowbank Manufacturing Co. (agricultural implements). The workshops generally are of up-to-date character and well equipped with all modern machinery, plant and tools for the economic application of labour and use of materials in the carrying out of works.

At Cockatoo Island there are two Government docks, one the "Fitzroy," about 500 ft. long, built by convict labour, capable of taking a 4,000 ton steamer, and the other the "Sutherland," completed in 1890, 608 ft. by 84 ft., with a depth of sill below high water, spring tides, of 32 ft., capable of taking any vessel at present entering the port. The docks are closed by caissons and emptied by pumps capable of discharging 45,360 tons of water in 3½ hours, the maximum lift being 36 ft.

Workshops for repairs and for construction of dredges and small vessels have been constructed on the island, and a good deal of general mechanical engineering work for the public departments carried out.

It is intended to instal electric power on a large scale shortly, taking current from the tramway power house at Ultimo.

Probably the Government workshops at Eveleigh for locomotive and general repairs yield to none in the State for efficiency and completeness. The buildings cover at the present time about nine acres of ground and represent a value of £350,000, including cost of land and machinery.

A notable feature is the large application of electric power, more especially to the overhead travellers, of which there are six 35-ton, four 25-ton, one 16-ton, and one 10-ton. There are also large electric milling and multiple drilling machines and some small lathes, and other machines similarly operated. The current is derived from the tramway power house at Ultimo There are a large number of hydraulic machines for riveting, punching, shearing, flanging, pressing, and hoisting, the power being supplied from an accumulator plant working to a pressure of 1,400 lbs. to the square inch. In addition to the numerous pneumatic tools, such as hammers, portable drills, &c., there are machines for cylinder re-boring, steam port facing, spring testing, and hoisting, operated by compressed air supplied by an "Ingersoll-Sargent" air compressor at 100 lbs. per square inch. The total horse-power is about 870, of which 370 h.-p. is derived from steam, and 500 h.-p. from electric current. In addition to ordinary repairs to locomotives and other rolling stock, the older engines are being continually reconstructed, fitted with "Belpaire" boilers, and turned out with a new lease of life.

In connection with the railways there are numerous other workshops at various centres throughout the State, the most important being at Newcastle, where a large structural steelwork for bridges, &c., is undertaken, in addition to the manufacture of points and crossings and carrying out of repairs, &c. The whole of the signalling and interlocking gear is now manufactured in the Redfern workshops.

The State Railway System.—In September last year there was held in Sydney an exhibition of railway plant and appliances as used in the State service, covering the whole field of action in a most complete manner and illustrating with great significance the immense progress made during the fifty years. The original train that left Sydney for Parramatta the 26th September, 1855, was placed alongside the present-day Melbourne express, and formed an epitome of the whole history.

The first railway contract let by private company, in March, 1851, had a chequered career. It had the misfortune to coincide in time with the discovery of gold, and labour was so scarce accordingly, and wages so hopelessly high, that it had to be abandoned. It was found necessary by the Government to import five hundred railway navvies from England before the contract could be carried on again. Later on the new contractor got into difficulties, and finally the Government bought up the works and also those being carried out in the Newcastle district, which had similarly come to grief.

Thus began the era of State railways in New South Wales. Twenty-five years later, that is in 1880, we find that the length constructed amounts to 849 miles, with a capital expenditure of £11,778,819, and the passengers carried during the year numbered 5,440,138; also that the train mileage was 3,239,462, the earnings per train mile 86·02*d.* and the working expenses 47·99*d.*; finally that the interest returned on capital invested was 4·35 per cent. Taking another leap of twenty-five years, which brings us to the present, we find that the length constructed has increased to 3,280¾

miles, the capital to £43,062,550, the number of passengers to 35,158,150, the train mileage to 10,467,886, and that the earnings and working expenses per train mile amount to 84·46 pence and 50·26 pence respectively, and interest on capital to 3·46 per cent.

The average cost of construction of all lines per mile is £10,904, but there is an enormous variation for sections in different localities. The last expensive line to be built was the Sydenham to Belmore, a double track, with numerous steel bridges of small span, for which the cost per mile was £37,691. A much cheaper class of construction, known as "Pioneer lines," was then inaugurated, and up to June, 1905, still fail to pay full interest on cost, their construction has been justified on the broad grounds of State policy. After a couple of blank years, owing to the necessity for economy in finance, construction has been once more resumed. Since the figures given were compiled 89¼ miles have been added, making a total mileage of 3,370, while 248 miles are now under construction.

The chief engineering difficulties encountered and overcome have been as follows:

The crossing of the Blue Mountains, which was met by the introduction of the famous Zig-zags, the smaller one of which, the Lapstone, was replaced some years ago by a tunnel, and the larger of which it is

CENTRAL RAILWAY STATION, SYDNEY. PERSPECTIVE VIEW.

covered a total mileage of 956 miles, at a cost of £3,496 per mile. These lines are mostly unfenced, and earth ballast has been largely substituted for stone, timber replacing steel for spans up to 60 feet, while the lines are located so as to avoid deep cut and banks. The maximum curvature is ten chains radius, which is approached always by four chains of transition based on the cubic parabola; this applies also to all curves from 12 chains to 20 chains radius, and it is now proposed to apply transitions to curves up to 40 chains radius. The trains travel at a maximum speed of 20 miles per hour, and a powerful electric head-light is used for night travelling. These pioneer lines have been of enormous assistance in developing valuable agricultural country, so that although most of them proposed to similarly replace; the crossing of the Hawkesbury River, which was bridged in seven spans, covering about 2,900 feet and costing £340,000, the material being of British manufacture, though the contract was carried out by an American firm; the piers are famed for the deep sinking involved in the foundations, about 170 feet below high water, and 210 feet from underside of bridge. Not far from the bridge is the largest tunnel in Australia—viz., 5,872 feet.

The great problem facing railway experts in the future is the unification of the gauge throughout Australia. New South Wales went back on her original intention to have 5 ft. 3 in. gauge as in the Colonies of Victoria and South Australia, and adopted 4 ft. 8½ in., in accordance with English practice. In

Queensland the gauge is 3 ft. 6 in. The goods traffic is a highly important factor in the development of the railway's earning, as it does about half the total income. The great fluctuation that takes place, due to the seasons, often strains the resources of the department. The handling of the different goods affords an interesting mechanical problem. More than half the total tonnage of the year, which is 6,418,596 tons, is in the carriage of coal, coke, and shale. At Newcastle this is handled as already described in the mining review above. Electricity will shortly be installed in this connection. At Penrith a coal elevator has been recently erected, together with crushers, hoppers, &c., to facilitate the coaling of engines, consisting of the usual series of buckets on an endless chain, the motive power being steam. The appliance will also lift ashes from the engine-pits and load them into trucks. At Darling Harbour the coaling of vessels is carried out by three steam cranes of fifteen tons capacity, and the handling of general goods by thirty-five hydraulic cranes of varying capacity totalling a lift of seventy-six tons. For handling grain in bags at Darling Harbour a special elevating and conveying plant was designed. Though largely of an experimental nature, conceived and carried out in a very limited interval of time to anticipate a heavy increase in the season's wheat, the plant was very successful. A bag placed by hand labour from the truck on to the link belt of the elevator can be sent for stacking to any part of the huge shed, 1,050 ft. by 80 ft., by a system of transverse and longitudinal conveyors, or direct to the ship's hold as the case requires. The plant is operated by twenty-six direct current reversible motors, 3½ h.-p., which give a belt velocity of 75 ft. per minute. In the yards electric capstans have been fixed to move the trucks along as required, and have proved very economical. The current is derived from the Ultimo Power House. The plant enables a record harvest to be handled without difficulty, ninety-four tons per hour being the maximum delivery into the ship's hold, and the average cost being 3¼*d.* per ton.

The necessity for more accommodation, and the increasing difficulty and danger of handling traffic in the Redfern yard, has led finally to the construction of a new terminal station on the large stretch of ground lying in front of the old terminus. This provides a platform length of nearly 9,000 ft. as against 5,384 ft. in the old station, about 30 per cent. of which was very ineffective, owing to shortness of some of the platforms. The new building when completed to the original design will accommodate the whole of the railway administrative staff, at present somewhat scattered. It is not intended at present to carry the building higher than the first floor, except the booking hall, which will be kept to its original internal dimensions of 100 ft. long by 54 ft. wide and 36 ft. high.

It was originally intended to cover the platform by a single roof, which in that case would have taken its place amongst the roofs of the world, but it was decided, for economic reasons, touching first cost and maintenance to, at any rate temporarily, adopt the umbrella type of roof now being carried out in timber.

The permanent way consists of 100 lb. rails. The tramway system will form a loop through the colonnade. Cabs will approach by an independent roadway and discharge their passengers on to a special platform on the west side.

The signalling appliances will be of a most elaborate character and worked on the electro-pneumatic system. Double jib water cranes at the head of each dock will replenish the locomotive tanks, drawing their supply through a 15 in. main from a 52,000-gallon tank fed from the city mains.

The total cost to date of the work proper, architectural and engineering, is about £331,000.

The Manufacture of Locomotives Within the State.—As far back as 1870, locomotives were made in the railway workshops and by Mort & Co. for the Government. Since that time various other firms, such as Vale and Lacy, the Atlas Co., and Henry Vale, have also manufactured them, the weights varying from twenty-two tons to sixty-three tons per engine, complete with tender, where such exists. In all sixty-three engines have been constructed, the price varying from £50 4*s.* 6*d.* to £115 4*s.* 8*d.* per ton. There are at present 623 locomotives in active service in New South Wales. During the wool and grain seasons they have been found barely sufficient to cope with the heavy traffic. The necessity for a large number of new engines, the depression prevailing in the iron industry, and the scarcity of employment for skilled mechanics were all contributing causes that led finally to the Government, in October, 1903, calling for tenders for the manufacture in the State of sixty locomotives, of which thirty were passenger engines, P. class, and thirty goods engines, T. class. Six tenders were received as follows;—

Fitzroy Dock, £312,737 15*s.* (£69 12*s.* 6*d.* per ton); Clyde Engineering Co., £361,380

(£80 10s. 4d. per ton): G. & C. Hoskins, £365,490 (£81 8s. 11d. per ton); and three others, one English, one German, and one South Australian firm, of which the two former with 12½ per cent. duty added were the lowest, but were informal, as they did not comply with the condition of manufacture in the State. A Royal Commission, appointed to enquire into the matter of accepting a tender, after examining all the conditions affecting the successful fulfilment of the contract--Fitzroy Dock was ruled out on account of the unsuitability of the site and necessity for a very large addition to machinery and buildings to enable the contract to be carried out. The Clyde Engineering Co.'s offer was considered reasonable, and the workshop, commanding both water and rail carriage, and admirably equipped with modern machinery, was commended as being in all ways suitable.

The company proposed to spend £8,000 in extending the building and £17,000 in the purchase of new machinery and tools, having already spent £5,000 in this direction in connection with a contract for eighteen locomotive boilers for the railways. Messrs. G. & C. Hoskins (whose workshops are chiefly employed in the manufacture of cast iron and steel pipes, including the famous locking-bar pipe) considered an outlay of £50,000 would be necessary to undertake the construction of eight engines a year, or £80,000 for twenty-four engines. In both cases, the order being an initial one with no certainty of renewal, each firm allowed a margin on the tender for covering portion of the capital cost of plant, so that a large order or an extension of orders would enable cheaper prices to be offered. The estimate of the locomotive branch of the railways was £71 12s. 3d. per ton or £322,260 for the sixty engines. The commission considered this estimate too high, and stated that the cost should not exceed £279,000, allowing that £25,000 would have to be spent on furthur machinery and accommodation, which would enable the engines to be manufactured per year. The majority of the commission were in favour of the railway workshops undertaking the contract.

For some time the whole question was shelved. Then the Clyde Engineering Co. offered to construct the engines for £71 13s. 11d. per ton, which was finally accepted, and the contract signed. Should the experiment prove successful, as it undoubtedly should, the day of imported locomotives is practically over, and a strong impulse to engineering industry in the State has been given at a most opportune moment.

The two classes of engines mentioned represent the latest and most approved types now running in New South Wales. The P class is a passenger engine weighing in full steam 88½ tons, with a maximum axle load of 14 tons. It has six coupled driving wheels 5 ft. diameter outside cylinders, 20 in. diameter and 26 in. stroke, and a tractive power of 22,187 lbs. The T class is a goods engine, weighing in full steam 107¼ tons, with a maximum axle load of 15½ tons. It has eight coupled driving wheels 4 ft. 3 ins. diameter, outside cylinders 21 in. diameter and 26 in. stroke, and a tractive power of 28,777 lbs.

State and Municipal Electrical Engineering.—The Department of Public Works, the Railway Commission, and the Water and Sewerage Board inaugurate and control the bulk of the civil engineering work done in the State. The work itself is generally carried out by private contractors, though in a number of cases, day labour has been resorted to, and, in the case especially of railway construction, with considerable success. The difficulty of eliminating political control, however, is always the rock on which that system is likely to split. Brief reference will be made to some of the more important state enterprises. Of these one of the most striking is the complete conversion of the old steam tram system in Sydney into an up-to-date electric system, enormously extended in its application. In 1899 there was about 80 miles of single track operated by steam and a few miles worked electrically; in 1900 we find 76 miles of steam track and 20½ miles of electric; at the present time there are about 130 miles of single track, all electrically operated, and about 700 electric motor cars haul the traffic. The original generating plant at Ultimo power house consisted of four sets of horizontal cross compound condensing engines of the "Allis-Reynolds" type with "Corliss" valve gear direct coupled to dynamos of 850 kilowatt capacity, supplying direct current at 600 volts, with a speed of 100 revolutions per minute, both engine and dynamo having a temporary overload capacity of 50 per cent. Fire tube boilers, three-throw electric feed pumps and auxiliary steam feed pumps, electric centrifugal circulating pumps, steam air pumps and "Wheeler" surface condensers practically complete the plant. All pumps are of "Blake" pattern. The smoke stack is 200 ft. high with internal diameter at base of 10 ft.

About four years later, owing to rapidly increasing traffic due to conversion of steam lines to electric and extension of service, the

plant was largely supplemented, both boiler and engine house being considerably lengthened. The fire-tube boilers were transferred to other fields, and thirty-two Babcock and Wilcox boilers with chain grate stokers and feed water heaters were installed. The generating plant consisted of three sets of vertical cross compound condensing engines of the "Allis-Reynolds-Corliss" type direct coupled to generators of the flywheel field pattern, the field forming part of flywheel rim and revolving within external fixed armature. Each set, running at 75 revolutions per minute, can deliver 1,500 kilowatts three-phase alternating current at 6,600 volts, and will take an overload of 50 per cent. for three hours. Two new stacks, 227 ft. high, 11 ft. inside diameter, were constructed, and a complete system of coal supply, crushing, conveying, and storing, and ash conveying installed, operated electrically. The high tension current is conveyed underground to sub-stations, where it is reduced to 375-volt three-phase alternating current by single-phase air blast transformers, and finally converted to 600-volt direct current by means of rotary converters.

A still more recent addition to the plant was the installation in January, 1905, of a "Parsons" turbo-alternator set of 1,875 kilowatts capacity, the largest electric unit so far installed in the Southern hemisphere. There is now, therefore, a total engine capacity of nearly 15,000 h.-p., and a total generator capacity of nearly 10,000 kilowatts. At the power house and all the sub-stations, large batteries, chiefly of the "German-Tudor" type, have been provided. The maximum lead for a high-tension cable is from Ultimo to North Sydney, a distance of 7,000 yards, of which 800 are submarine. The total output for the plant for the year ending June 30th, 1905, was 33,555,887 kw.-h., of which 19,110,640 kw.-h. were supplied on the a.c. system, and 14,445,247 kw.-h. were used for other purposes than traction, such as electric lighting, signalling, driving machinery, and operating the steel draw spans on the Pyrmont and Glebe Island bridges. Most of the sewerage of the low level area of Sydney is pumped by electric power from Ultimo, into the high level system. The underground stations, of which there are a large number, are in touch with a central controlling station, but the pumping goes on automatically as required.

In contrast to the above machinery, which is mainly of American manufacture, the plant used for the City electric lighting, which is under municipal control, is entirely of British origin. The power house has room for machinery up to 30,000 h.-p. The steam is supplied from Babcock and Wilcox boilers with chain grate stokers, feed water economisers (Green's) and superheater—complete coal and ash conveying plant is provided—all auxiliary pumps, except for feed water, are electrically driven—engines are of the vertical cross compound quick speed "Ferranti" type, with special valve gear generators. "Dick-Kerr" three-phase a.c. type, supplying 5000 volt current with periodicity of 50 cycles. The total horse-power available is 5,900. The high tension current is conveyed underground to substations, at two of which it is converted by motor generators into direct current for distribution on a three-wire network at 240 and 480 volts; elsewhere conversion is by means of static transformers for distribution on four-wire three-phase a.c. network at 240 and 415 volts. The current was first switched on on July 8th, 1904.

Besides Sydney, electric lighting has been adopted at Redfern, Newcastle, Penrith, Tamworth, Young, Hillgrove, and Moss Vale; at all these places with the exception of Moss Vale, the municipality owns the plant. At Hillgrove the motive power is derived from a waterfall.

Some large pastoral stations have recently had electric lighting sets installed.

Water Supply—Irrigation and Artesian Boring.—Of all the dreaded evils that haunt the mind of the Australian miner, pastoralist, and agriculturist, water famine stands at the head. It must be candidly admitted that in the good years there is an abundance of rainfall which should tide us over the bad years, but we learn our lessons very slowly. Of late there has been an eagerness to put all other things aside and concentrate attention on the question of conserving water. It seems likely that the next few years will see a large devotion of engineering skill and knowledge and a considerable outlay of money in this direction.

Even Sydney, with its 50 ins. of annual rainfall, is not untroubled by spectres of this character. As the result of a recent scare, the big dam over the Cataract River is now under construction and will conserve a volume of water amounting to 21,000,000,000,000 gallons. The height of top of waste weir above river bed is 150 ft.

A still larger dam will be built near Barren Jack, if the great irrigation scheme formulated by the Works Department is approved by Parliament and funds voted for its construction. The dam will be 200 ft. high, and impound about 33,000,000,000,000 cubic ft. of water—which will be distributed over an immense area by means of canals.

As one recedes westward from the coast of New South Wales the average annual rainfall gets less and less; west of the Darling River it does not amount to 10 ins. per year. Fortunately if nature has been niggard above she has been bountiful below, and artesian bores now cover a large area of country, yielding a liberal supply. There are at present about eighty-four flowing bores, put down or controlled by Government, aggregating a length of approximately 155,000 1 in. and yielding a daily flow of 52,000,000 gallons, twenty-six pumping bores aggregating 37,000 ft., of which a good number show no sign of exhaustion under pumping. In sixteen cases failure arose owing to either no water being struck or on account of the water being too salt for consumption. There are ninety-six other private wells flowing and pumping, but the flow has not yet been accurately computed. The deepest bore is at Dolgelly, 4,036 ft., from which the daily flow is 700,000 gallons at a temperature of 130°. Recently a 6 in. diameter bore has been put down at Euraba 4,002 ft., yielding 800,000 gallons. The maximum flow is from a bore at Kenmare 1539 ft., yielding over 2,000,000 gallons per day.

Bridge Building.—Steel bridges up to 200 ft. span and composite timber and steel up to 105 ft. have been designed and manufactured in this State both for road and for railway purposes. Every variety of opening bridge has been constructed, the Pyrmont and Glebe Island spans affording excellent examples of high speed openings for frequent cross traffic, operated electrically (cost of opening ¾*d.*, time 46 seconds), while the most satisfactory for occasional operation by hand power has been found to be the bascule single leaf type, with counterweights rolling on curved tracks, and the vertical lift type with counterweights hanging plumb on the four corners. "Monier" cylinders are gradually replacing iron for sinking of piers, while "Monier" sheathing for timber piles and wharves has been found satisfactory in tidal rivers, &c., where teredo and other marine worms work mischief. Concrete-steel has been rapidly coming into favour, and has a most extended application in arched bridges, reservoirs, building foundations, piles for driving, sewer pipes, &c.

Summary and Future Prospects.—The introduction of electric power, following rapidly on that of pneumatic and hydraulic, has already effected a mild revolution in the modern mill and workshop. The recent improvements in producer gas plant with its highly economical utilisation of fuel energy in place of the wasteful method of the steam boiler seem to have developed a formidable rival to that once indispensable item of plant. Several installations have been made in this State with satisfactory results. Engines for utilising crude oils should also have a great future. The great deficiency in this country is the scarcity of cheap motive power. The Snowy River may at some future date render service in this direction and supply cities in the south with light and power over a wide extent of country. Automobiles are now a familiar feature on our roads, and great interest attaches to the reliability contests held annually between Sydney and Melbourne. Recently the Railway Commissioners have introduced motor omnibuses to convey passengers on lines of traffic in the city where at present no tramways exist. Experiments on a cheap form of railway for mountainous country will shortly be made in connection with the introduction of the "Shay" locomotive, which is capable of negotiating 4-chain curves and 1 in 20 grades.

The larger public works likely to be constructed during the next decade will probably include the North Coast Railway (involving the crossing of some large rivers), the North Shore Bridge, for which competitive designs have already been twice received (or as an alternative a tunnel under the harbour). Electrification of the suburban railway system, the Murrumbidgee and Murray River Irrigation and Canalization Schemes, and building of the Federal Capital.

In conclusion, the writer returns thanks for assistance afforded him in the compilation of this article, and to the Department of Works for kindly supplying the photographs which accompany it.

Engineering in Natal.

By the courtesy of the Colonial Secretary for Natal, we are able to present on the five succeeding pages, reproductions from an interesting series of photographs illustrating some of the various workshops and engineering undertakings of the Railway and Harbour Departments of that Colony. The following is a brief description of the illustrations :—

1. *Quay Wall Construction at Port Natal.*—The view shows staging for a length of 1,700 ft. of quay wall, being constructed with concrete blocks, providing a depth of 30 ft. at low water ordinary Spring tides. Travellers for lowering the blocks are seen on the staging.

The area between the staging and the retaining bank is to be filled in by suction dredgers as soon as the wall has reached high water level. This length of wall will be used for the coaling plant now on order.

2. *Floating Dock at Port Natal.*—The view shows the ss. *Maine* (length, 492·0 ft.; breadth, 58·3 ft.) docked for repairs.

The dimensions of the dock are as follows: — Extreme length over platforms, 475 ft.; extreme beam, 96 ft.; width of entrance between fenders, 70 ft.; width of entrance at level of top of altars, 61 ft.; draught of water over keel blocks, 23 ft.; time of lifting a vessel displacing 8,500 tons, 2½ hours.

3. *Port Natal—Dredging.*—Sea-going suction dredger *Cetus*, hopper capacity 3,000 tons. Capable of pumping clean sand at the rate of 3,000 tons per hour. Built by Messrs. Simons & Co., Renfrew.

4. *Natal Government Railway Corridor Train, used for through traffic to Johannesburg.* — It is drawn by a locomotive designed by the present Locomotive Superintendent, Mr. Hendrie, and has axle loads of 15 tons.

5. *The Machine Shop of the Natal Government Railways*, forming part of the new erecting shops at Durban, which consist of three bays of 48 ft. 6 in. span, having a length of 362 ft., and five bays of similar span having a length of 200 ft. The machine shop occupies one bay having a length of 561 ft. by 48 ft. span, and a short length of 200 ft. with a similar span. In this are centred the majority of the lathes, drilling, shaping, and other machine tools, each driven electrically by a separate motor. The remaining two bays are used for the erection of engines, and are provided with three 35-ton electric gantry cranes each. The boiler shop is situated in this building, and is also provided with electric cranes and a pneumatic plant, by means of which all the smaller hand-tools are worked. Hydraulic plant is being installed, by means of which flanges and other heavy forgings will be carried out.

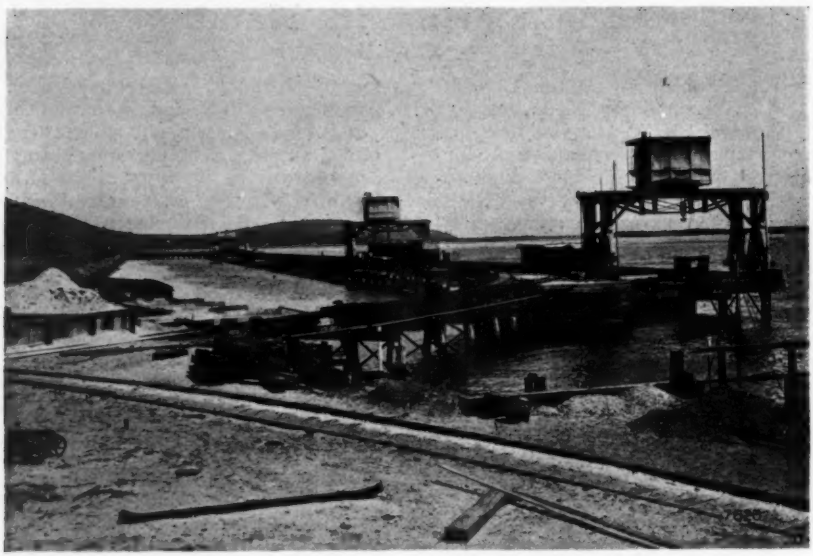
6. *The Colenso Bridge, Natal Government Railways.*—The view shows the bridge, which has five 100 ft. spans, under construction.

7. *Botha's Hill Cutting on the main line of the Natal Railway System.*—The view shows the 300 ft. curves on gradients of 1 in 30 and 1 in 46.

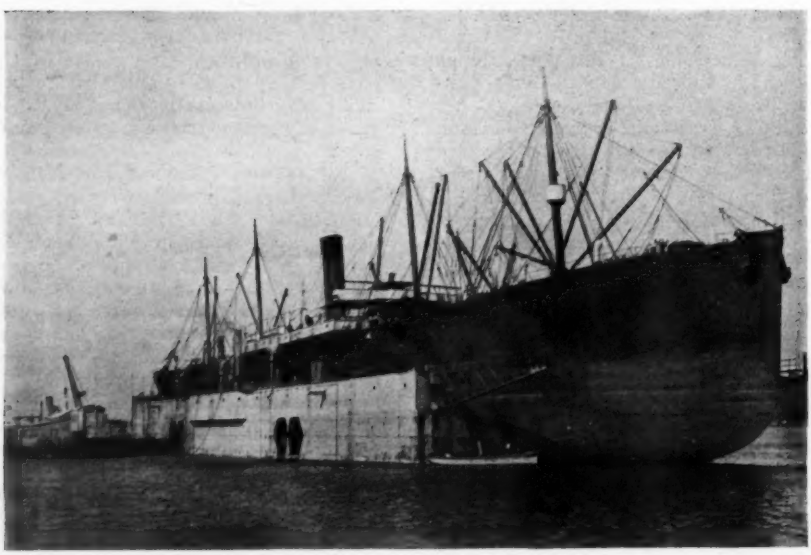
8. *The New Carriage Erecting Shop of the Natal Railway.*—It consists of two bays with spans of 47 and 48 ft. respectively, each having a length of 397 ft. 6 in. Each bay is fitted with a 5-ton gantry crane.

9. *Floating Workshop at Port Natal.*—This craft is self-propelling (twin screws), and can be used as an adjunct to the floating dock for repair work, &c. The machinery consists of lathe, shaping machine, radial drill, pillar drill, punching and shearing machine, all coupled direct to electric motors. Steam hammers, two smith's hearths, and other appliances. A 15-ton revolving jib crane is also provided.

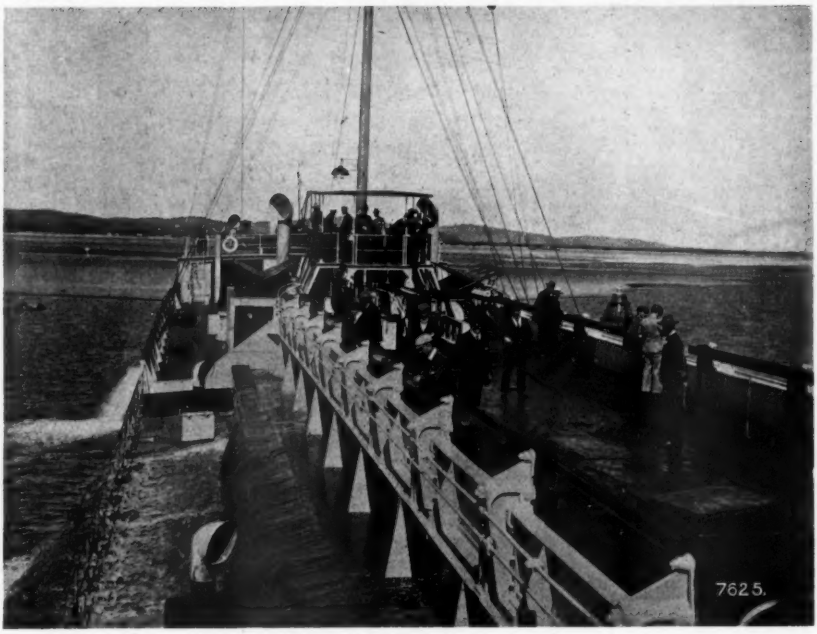
10. *Block Building Gantry: Port Natal.*—The gantry is used for building concrete blocks for the quay wall, and is 1,500 ft. in length, with a span of 135 ft. The electric traveller is capable of stacking blocks of 20 tons weight to a height of 16 ft., and the time occupied in travelling from end to end of the gantry is 3½ minutes.



1.—PORT NATAL: QUAY WALL CONSTRUCTION.

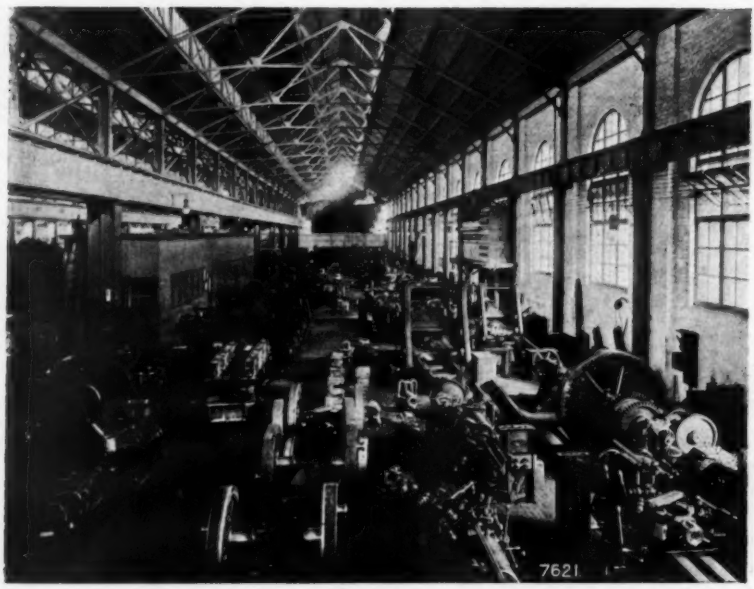


2.—PORT NATAL: FLOATING DOCK.



3.—PORT NATAL: DREDGING.

4.—NATAL GOVERNMENT RAILWAYS: CORRIDOR TRAIN.

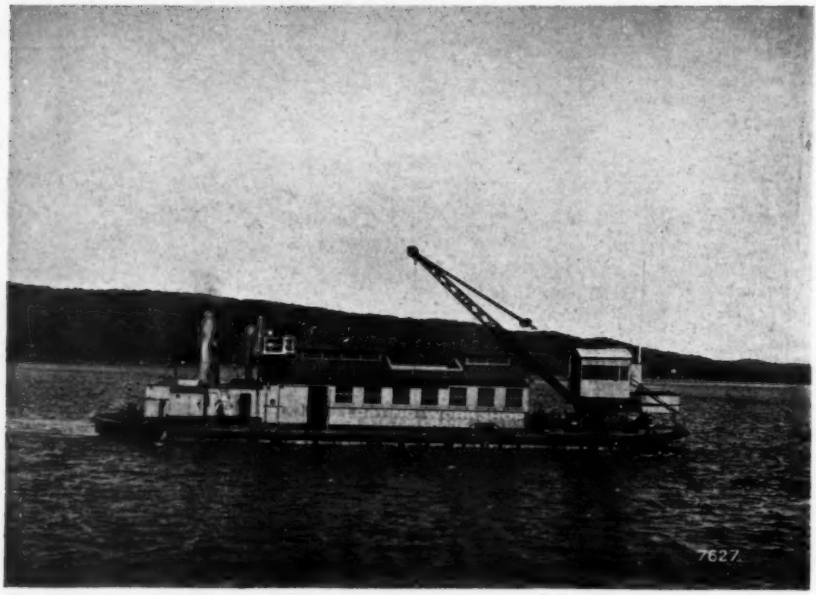


5.—NATAL GOVERNMENT RAILWAYS: MACHINE SHOP.

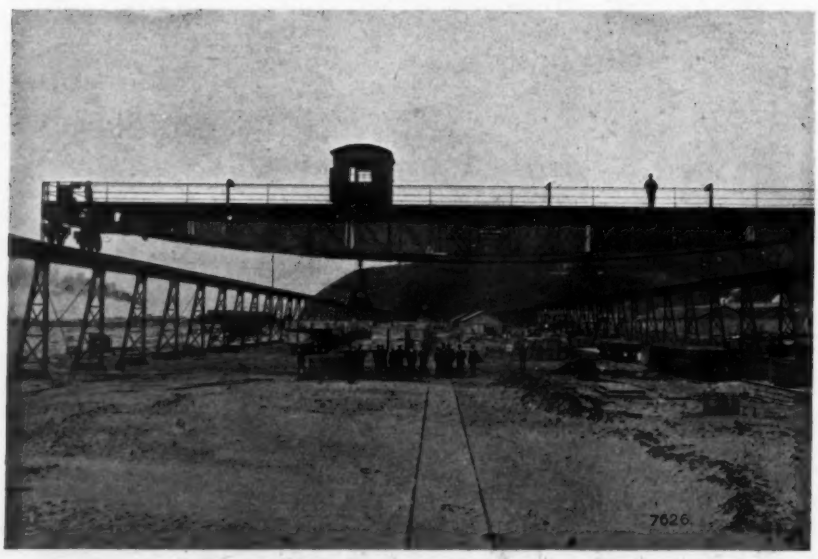
6.—NATAL GOVERNMENT RAILWAYS: COLENSO BRIDGE.

7.—NATAL GOVERNMENT RAILWAYS: PORTION OF MAIN LINE.

8.—NATAL GOVERNMENT RAILWAYS: CARRIAGE ERECTING SHOP.



9.—PORT NATAL: FLOATING WORKSHOP.



10.—PORT NATAL: BLOCK BUILDING GANTRY.

Locomotive and Railway Engineering.

By CHAS S. LAKE.

New Compound Locomotives; North Eastern Railway.—An interesting development in locomotive practice has recently taken place on the North-Eastern Railway, where the chief mechanical engineer, Mr. Wilson Worsdell, M.Inst.C.E., has introduced two four-cylinder balanced compounds, Nos. 730 and 731, for working heavy and fast passenger traffic, principally on the East Coast Anglo-Scottish services between York and Edinburgh.

The engines are of the 4-4-2 type, and have the four cylinders arranged in line at centre of the bogie; two inside and two outside the frames, and all driving the leading coupled wheels.

The four steam-distributing valves are actuated by two sets of valve-gearing. In the case of engine No. 730, this is of the ordinary Stephenson link-motion type, but slightly modified, whilst engine No. 731 has Walschaerts' motion also modified to suit the circumstances. The arrangement will, it is hoped, be illustrated and described in a later issue. The boiler is fitted with a "Belpaire" firebox, this constituting a further new departure in locomotive design on the North-Eastern Railway; it contains less heating surface than is provided by Mr. Worsdell in his previous "Atlantic" type "simple" locomotives, but on the other hand it has a larger grate area and higher steam pressure.

The cylinders are compounded on Mr. W. M. Smith's system, this being the first adaptation of that system in a four-cylinder form.

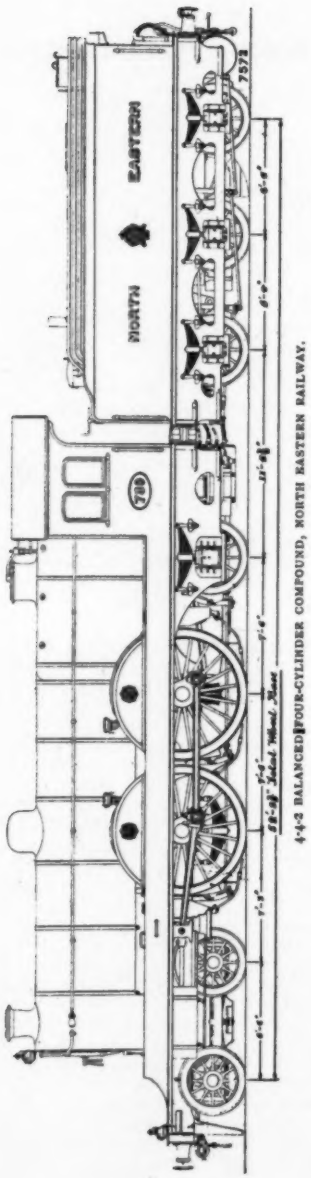
The North-Eastern Railway was originally noted for the number of compound locomotives in use thereon, these were of the two-cylinder type, designed by Mr. T. W. Worsdell, brother to the present chief mechanical engineer. They comprised single driving and 4-4-0 type express locomotives, also goods and tank engines, and all were compounded on the Worsdell-von-Borries-Lapage system. In 1898 Mr. Wilson Worsdell took No. 1619, one of the 4-4-0 type engines, into the shops at Gateshead and converted it from a two-cylinder 19 in. (high-pressure) and 24 in. (low-pressure) by 24 in. compound into a three-cylinder engine on the "Smith" system.

This constituted the only step taken by him towards the perpetuation of the "compound policy" on the North-Eastern until his recent introduction of the balanced engines of the 4-4-2 type, Nos. 730 and 731. Both of the locomotives are now in regular working and are giving the utmost satisfaction in acclerating heavy trains rapidly and hauling them at high average speeds on up grades and along the level. The principal dimensions are:—

Cylinders high-pressure, 14½ ins. diameter by 26 ins. stroke.	
,, low-pressure, 22 ,, ,, ,, ,,	
Coupled wheels, 7 ft. 1½ ins. diameter.	
,, wheel base, 7 ft. 6 ins.	
Bogie ,, 6 ft. 6 ins.	
Total engine and tender, 52 ft.	
Weight of engine in working order	73 tons.
,, tender ,, ,, ...	42 ,,
Total	115 ,,

Criticising the District Railway.—The protest of Sir George S. Gibb, deputy chairman and managing director of the District Railway, against what he describes as a "perpetual shower of virulent and premature criticisms" of that line, which have appeared in the columns of certain London daily papers, is what might certainly have been expected in course of time, for there can be no doubt that the language employed in some quarters when speaking on this subject has often been of a highly exaggerated description, and it is only natural that Sir George should wish to defend his company against what he regards as unfair and, in many cases, inaccurate statements regarding the equipment and working of the railway.

At the same time, no one can ignore responsible criticisms appearing in the engineering and railway press, and these on occasions have hardly been more favourable to the District management than those of the daily papers, in spite of the more sober language employed. Those who understand the difficulties attending the work of substituting electric traction for steam services, especially on a line such as the District—running as it does through the



heart of the Metropolis—can readily appreciate the unenviable position in which the authorities must at times have found themselves, but even these circumstances do not altogether alter the fact that many and persistent causes for legitimate complaint have existed—in the past at all events—from the point of view of the travelling public.

It can hardly serve any useful purpose to revive on this occasion the point relating to the use of foreign built rolling stock on the District Railway, a matter already commented upon in these columns, but certain knowledge exists, outside official circles altogether, that many of the cars purchased from abroad have proved highly unsatisfactory in service.

Sir George Gibb, in his letter of protest, explains away the matter of the broken axles by stating that it was only those of the trailing bogies of the motor cars which fractured, through having been designed insufficiently large in section for the weight they had to bear, and they have, he says, now been replaced, at a cost of £1,700, by new axles of larger section made by the Monkbridge Iron Company of Leeds. Another step in the right direction has been the closing of the central sliding doors—one of the maddest ideas ever introduced as a feature of rolling stock design on any railway in this country—for it is certain that sooner or later a fatal accident would have occurred had their use been persisted in. On several occasions to which the writer was a personal witness, passengers only escaped grave injuries by the narrowest possible margin through the doors being closed whilst passengers were in the act of passing through them, and it is difficult to see how the company could have defended themselves successfully in an action brought against them for personal injuries sustained from this cause; their rules and regulations notwithstanding. It is to be hoped that the present announcement appearing on the doors, to the effect that the latter are "temporarily" out of use will be altered so as to read permanently out of use. The unnecessary clanging of bells when the trains are ready to leave the stations, added to the excessive rattling of windows and other annoyances experienced while riding in the cars may all be regarded as contributory features towards the popular discontent manifested not only by the utterances of the press, but also overheard so frequently in the trains themselves.

The worst part of the whole business for the District people is that alongside them they have an example of how the thing should be done, as demonstrated by the Metropolitan Company, whose cars, and

services also, are beyond question superior to those of their contemporaries using the same lines. The latter suffer by comparison, and perhaps it is only natural that the public should judge accordingly. It is beyond dispute that there is much in connection with the District Railway which needs reforming, and now that Sir George Gibb is at the head of affairs, the process of reformation will doubtless be expedited and brought to a successful conclusion as early as possible.

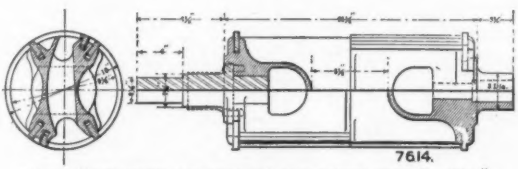
The "Young" Valve Gear.—The Delaware and Hudson Railroad Company have recently placed in service four large 4-6-0 type locomotives, two of which are fitted with the "Young" valve and valve-motion.

The gear is an adaptation of the "Corliss" principle for locomotives. It employs rotating valves operated from a wrist plate which is oscillated by a connection from the rocking shaft. The gear differs from the "Corliss" principally in that one valve is used for both admission and exhaust control, and that the wrist plate pivot is movable. This pivot is fastened to the end of one arm of the bell crank, the other arm of which has a direct connection to a short crank arm on the reversing shaft and the fulcrum of this bell crank is rigidly secured to the cylinder casting.

The special feature concerning steam economy which this valve introduces are that a constant steam lead is maintained at all points of cut-off, and the exhaust lead is increased as the cut-off is shortened. The valve gives a very rapid cut-off, preventing wire-drawing at this point and in the same manner opens readily, giving a full port opening for the admission.

The increasing exhaust lead gives an exhaust closure when the locomotive is working at high speed on a short cut-off, all these comparisons being made with the ordinary slide-valve. The design of the gear permits, by arranging for two passages, of a larger port opening than would be possible with either a slide or piston valve. The area of the steam ports in the Delaware and Hudson locomotive are 32 sq. in. as compared with 24¾ in. for a slide valve engine of the same type.

The illustrations, which are from the *American Engineer and Railroad Journal* of New York, clearly show the mechanical features. The valve chambers and all connecting passages are included in the cylinder casting, there being two valves for each cylinder, each set directly above the port entering the cylinder being 11½ in. diameter, 22½ in. long inside the bushing, and having their axes at right angles to that of the cylinder. A supplementary passage extends from the top of the valve chamber around the outside and joins the one going



VALVE—"DELAWARE AND HUDSON" LOCOMOTIVE WITH "YOUNG" VALVE AND GEAR.

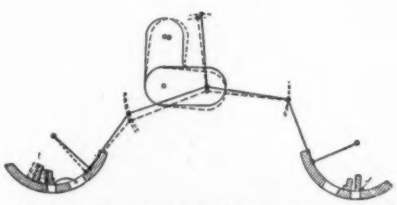
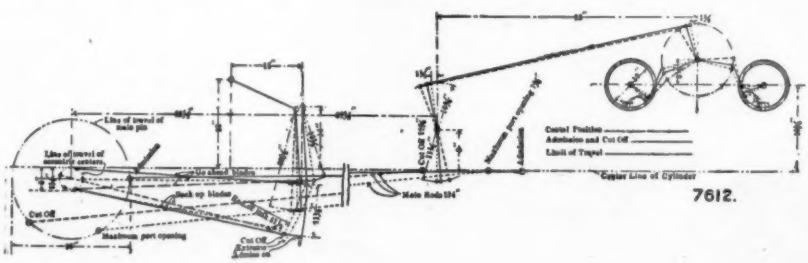


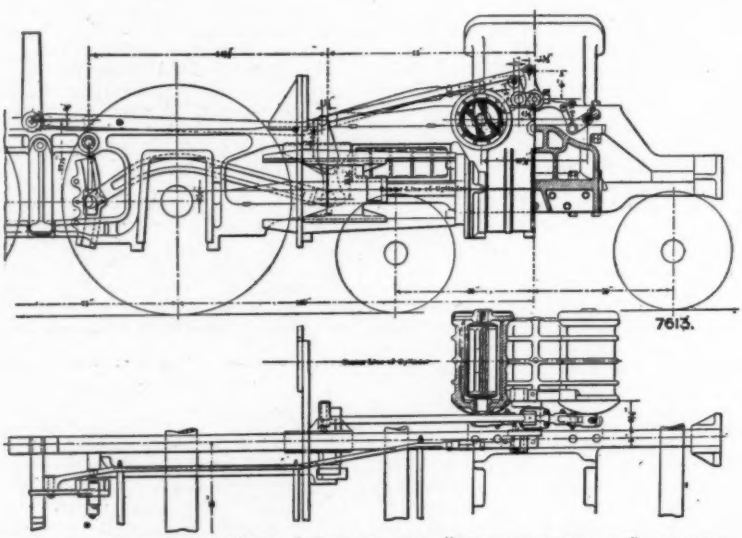
DIAGRAM SHOWING THE EFFECT OF MOVING WRIST PLATE FULCRUM ON EXHAUST LEAD—"YOUNG" VALVE GEAR.



from the bottom of the chamber directly to the cylinder.

This allows the steam to have two passages, and with the same amount of port opening gives a length equal to twice the length of the valve strip; the exhaust steam follows the same path. The passage of the steam to and from the cylinder is more direct than that usually found in the slide or piston valve.

The back cover of the valve chamber is cast integral with the cylinder casting and only has an opening for the valve spindle; the front cover is, however, removable.



GENERAL ARRANGEMENT OF THE "YOUNG" VALVE AND GEAR—"DELAWARE AND HUDSON" LOCOMOTIVE.

The design of the valve itself is also shown. It is constructed of cast iron of a light section and of peculiar shape. The packing strips, of which there are two on the controlling side and one narrow one in the wall separating live from exhaust steam, are similar to those used in the "Richardson" balanced valves, having light flat springs to hold them against the chamber wall. There are also packing strips extending around the ends between the longitudinal strips for preventing leakage at this point. These are separate pieces and they abut on the ends of the other strips.

The stem, which is of steel, fits into one end of the valve and is fastened with four dowels. This stem extends through the inner chamber head and carries the arm through which the valve is operated. The method employed for making a steam-tight joint is as follows: A brass bushing is fitted into the casting and turned to a taper of $\frac{1}{2}$ in. in 12 in. on the inside for a distance of $2\frac{1}{2}$ in. A $\frac{1}{4}$ in. lip is formed on the outer end against which the shoulder of the valve stem, which is turned to make an exact fit in this bushing, rests. The valve stem also rests against the inner face of the bushing, where there are a numbcr of grooves cut to allow a small amount of steam to pass round the stem and lubricate the bearing. On the opposite end of the valve, the bearing is made in the head, and steam pressure between this and the valve holds the latter up against the shoulder of the inner bearing. A coil spring holds it in place when steam is shut off.

This method, which employs no packing of any kind and needs no attention as to lubrication, has proved very satisfactory. The coil spring rests against a steel button which prevents the spring affecting the rotary action of the valve.

The arms on the valve stem are securely keyed, but in such a manner that they are easily removed when it is desired to remove the valve from the chamber; these arms connect to the wrist plate through the short

links. The wrist plate, as before mentioned, has a movable fulcrum, operated from the reversing shaft, and all of this construction is heavy and rigid.

The connection from the bell crank to the reversing shaft is direct, and in this case is made by two rods fastened to the reversing shaft arms a short distance from the shaft and cross-braced for stiffness. This connection has a nut for adjusting its length.

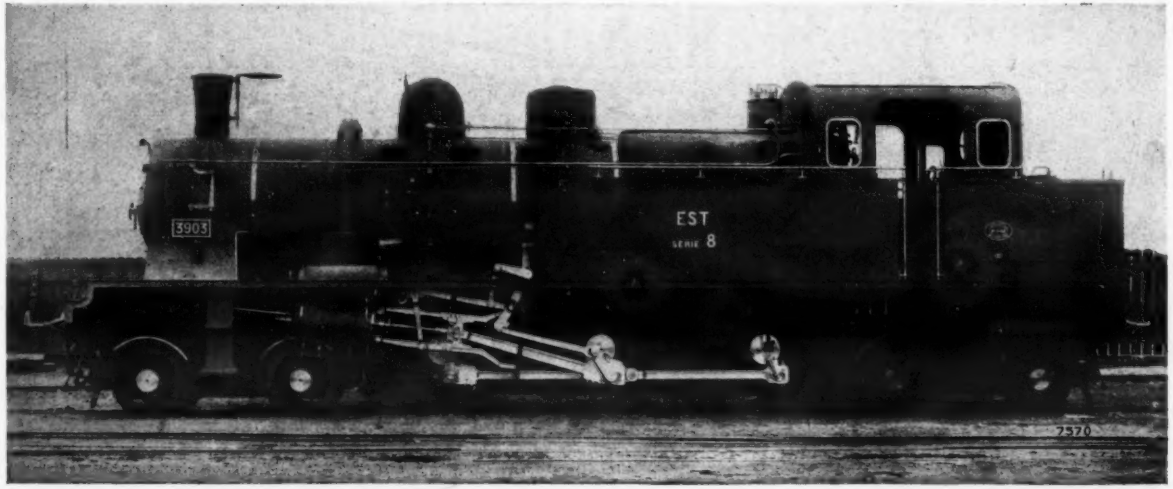
Connection from the rocker arm to the wrist plate is through a rod very similar to the ordinary valve rod, which is not adjustable.

The engines fitted with this gear on the Delaware and Hudson River Railway were only put into service recently, but they are reported to be giving excellent results. Three other companies are about to introduce locomotives fitted with it.

New Compound Tank Locomotives—Eastern Railway of France.—The Société Alsacienne de Constructions Mecaniques have recently delivered to the Eastern Railway of France some large and powerful 4-6-4 type "de Glehn" system compound tank locomotives, which they have built at their Belfort works. One of the series is illustrated herewith from originals kindly supplied by the builders.

The leading and trailing ends of the engine are each carried upon a four-wheeled bogie, and the six-coupled wheels are grouped between them. The outside high-pressure cylinders drive the middle axle and the inside low-pressure cylinders the crank axle of the foremost coupled wheels, separate valve gears of the Walschaerts' type being used for each cylinder.

The boiler has a Belpaire firebox, and the standard fittings



4-6-4 TYPE COMPOUND TANK LOCOMOTIVE. EASTERN RAILWAY OF FRANCE.

and equipments for the latest Eastern of France practice are provided throughout. The engines, which have been built for working heavy trains on the more difficult sections of the line, have dimensions as follows :—

Cylinders, high pressure	14 in. dia.
„ low „	22 in. dia.
Stroke	25½ in.
Bogie wheels	2 ft. 10 in. dia.
Coupled „	5 ft. 3½ in. dia.
Bogie wheel base	6 ft.
Coupled „	13 ft.
Total	36 ft.
Boiler	5 ft. mean dia.
Number of tubes	229; 1⅞ in. dia.
Length „	14 ft.
Heating surface, tubes	1432·6 sq. ft.
„ „ firebox	150·7 „
Total	1582·13 sq. ft.
Grate area	26 sq. ft.
Steam pressure	227 lbs. per sq. in.
Weight, empty	70¼ tons.
„ loaded	88¾ tons.

Francis W. Webb.—Only some three years have elapsed since Mr. F. W. Webb retired from the position which, for thirty-two years, he had filled with such conspicuous success as chief mechanical engineer of the London and North-Western Railway, and now death has brought to a close a life for the most part devoted to the improvement of railway machinery and the better organisation of the department of railway service with which the subject of this memoir was so long and prominently associated. Another great name has been added to the list of eminent engineers deceased, a name which will always figure prominently wherever locomotive men are congregated and locomotive history is the subject of discussion.

Mr. Webb was conspicuous for the determination and exceeding candour of his disposition. He cared little for outside opinion once he had made up his mind as to the course he meant to pursue regarding matters coming under his control. For years the chief exponent of the compound locomotive in Great Britain, he never relaxed his belief in the possibilities of that principle, despite the fact that in this matter the great body of contemporary opinion was against him.

To those engaged in responsible engineering journalism he was generally ready to afford information relating to the design and working of his engines. He had no cause to be, and never was, afraid of the truth being known about them, and if at times he found himself unable to accede to requests for information, it was invariably with the utmost courtesy that he declined.

The present writer has the most pleasant recollections of more than one interview with Mr. Webb, in the latter's office at Crewe, and especially of the occasion when, at the "chief's" suggestion, a visit was arranged for the purpose of collecting material for a technical description of the works, which in due course was published in an engineering contemporary.

The facilities then afforded were the most complete that could be wished for, whilst on several subsequent occasions information respecting locomotives and other matters connected with the department was readily provided.

Mr. Webb displayed considerable originality in all that he did. In designing locomotives he was not content to follow slavishly in the footsteps of others, relying merely upon a few outward dissimilarities and perhaps a dimension here and there larger than those employed by his contemporaries, to distinguish his engines from theirs. He possessed unlimited courage, and wielded an influence which was felt on the North-Western far beyond the precincts of Crewe works, or, indeed, the ramifications of his own department.

Those who disagreed with Mr. Webb's locomotive policy have attempfed to make capital out of the fact that his successor, Mr. George Whale, has entirely reversed that policy. There has been a lot of talk about "raising the standard of locomotive efficiency on the London and North-Western Railway," and so forth, but it might be as well if some of these pseudonym critics would first acquaint themselves with all the facts before committing themselves to this and other statements of the same kind. In any case Mr. Webb's unique reputation will never suffer on this account among those who understand the circumstances.

Metallurgical Progress.

By PERCY LONGMUIR.

Researches by the Carnegie Scholars of the Iron and Steel Institute.

LAST month we were compelled to withhold a reference to these papers, the abstracts of which cover some sixty-four pages of the Institute's proceedings. Owing to their being in abstract form it is no easy ask to form a just estimate, or yet to select the more salient features of the various reports. Generally speaking, the work of Messrs. Brunton and Hatfield is of a very practical character, that of Messrs. Roberts and Wraight is extremely suggestive, whilst M. Guillets' contribution, even in abstract form, is voluminous and indefinite. However, taking the papers individually, the following points are worthy of note.

Quarternary Steels.—M. Guillet has examined a series of about 250 varieties of alloy steels, the general results showing that the commercial applicability of many of the steels is restricted. Taking the structure as a guide it is shown that if the tendency of the alloy is towards a graphitic or martensitic steel such products are useless. If the tendency is to form a special carbide with, at the same time, a pearlitic or sorbitic structure, then the chief application lies in the direction of tools as exemplified in high speed steels. In general, the type of the structure most desirable is a pearlitic one, a feature which at once limits the addition of special elements to relatively low proportions. Of these steels, with the special elements comparatively low, the most interesting are (1) nickel vanadium, (2) nickel tungsten, and (3) chromium-vanadium.

The Heat Treatment of Wire.—Mr. J. D. Brunton, working on commercial steels and experimenting under works conditions, gives a careful analysis of the processes followed from the rod to finished wire. Taking Sample I., which originally contained 0·75 per cent. carbon, the following table gives a good index of the work presented.

Other tables are given, and, on the whole, the results show many features of interest. We note especially the author's deduction that a steel of 0·75 per cent. carbon is best drawn to stand 95 tons per sq. in., and a steel containing 0·83 per cent. carbon to stand at 105 tons per sq. in., as at these points the most useful work can be obtained from the steel before it breaks up. The specific gravities are of special interest, showing that by cold work it is possible to obtain an increase of from 7·768 to 7·998, but from this point further wire

TABLE I.

	Reduction per cent.	Maximum Stress.	Elongation per cent. in 8 in.	Torsion in 100 diameters.	Specific Gravity.	Rate of reduction in feet per minute.	Remarks.
1st pass	5·5	68·4	7·0	33	7·768	142	—
2nd ,, ...	4·7	72·1	6·25	38	7·779	142	—
3rd ,, ...	5·5	75·0	4·5	23	7·795	142	Unequal torsion.
4th ,, ...	5·3	77·5	4·5	28	7·812	142	,, ,,
5th ,, ...	6·2	80·0	6·25	41	7·819	142	— ,,
6th ,, ...	7·2	83·0	5·0	37	7·841	142	—
7th ,, ...	7·1	85·5	4·0	44	7·853	142	—
8th ,, ...	7·7	89·5	4·5	40·5	7·872	142	9 bends
9th ,, ...	7·5	90·5	4·0	44·5	7·888	142	9 ,,
10th ,, ...	10·0	96·0	3·5	40	7·893	142	12 ,,
11th ,, ...	10·0	99·0	6·5	42·5	7·916	142	15 ,,
12th ,, ...	10·0	104·0	6·0	42·5	7·933	142	19 ,,
13th ,, ...	12·0	115·0	3·0	41	7·950	332	22 ,,
14th ,, ...	13·9	121·0	3·0	32	7·972	225	32 ,,
15th ,, ...	16·0	136·0	3·5	37·5	7·991	225	35 Unequal
16th ,, ...	20·0	165·0	2·8	21	7·998	225	36 torsion.
17th ,, ...	10·0	152·0	3·1	14	7·997	225	35

drawing lowers the specific gravity. A further interesting point is found in the fact that a slight decrease in carbon is associated with a slight decrease in phosphorus, and as the missing phosphorus is not found in the scale, it would almost appear that it had gone off in volatile form, just as carbon similarly is, no doubt, lost as carbon monoxide.

The Influence of the Condition of the Carbon upon the Strength of Cast Iron.—Mr. W. H. Hatfield in the first place determined the influence of silicon and casting temperature within the sphere of his research. Taking the influence of silicon first, a series of tests were conducted on irons varying from 0·25 to 2·50 per cent. silicon, and the results obtained showed a considerable difference from those obtained by Professor Turner. Thus excellent results were obtained from the low silicon end of the series, and in particular one test bar gave a maximum stress of 22·8 tons per square inch. From the casting temperature experiments, it was generally found that the "cold" test bars gave poor results, but the "high" bars did not give such low results as expected from a perusal of Longmuir's work on this subject. Casting temperature did not seem to be the controlling influence, and variations of tensile occurred irrespective of the said influence. Further, to test Longmuir's results, the whole of these test bars were annealed together under the same conditions, and then it was found that variations in tensiles in the cast state did not persist after heat treatment. Passing on to the next portion of the work, the author found that the highest tensiles were almost invariably given by the low silicon irons in which combined carbon was at a maximum. With regard to mottled irons, the strength of these seemed to be dependent on the amount and condition of the cementite. Grey irons gave the most inferior tensile results, a feature explained by the weakening action of the graphitic plates. Pearlite considerably strengthens grey irons, but it was found that owing to the usual conditions of the formation of grey iron, coarse graphite and low percentages of pearlite occurred together, hence the low results. Finally, the results on the whole show that white irons are the strongest, but it is noted that the structure of the cementite upon which the iron seems to depend for its strength cannot be obtained with certainty. For general work this hard iron would be out of court, owing to its comparative brittleness and to the extreme difficulty of working it. The author believes that the best iron for strength, as cast, is one containing the maximum amount of combined carbon practicable under the particular working conditions. With regard to heat treated irons, it is obvious that grey irons are weakened by annealing, and that white irons are rendered much stronger. The strength of the heat treated white irons is undoubtedly considerably influenced by the condition of the free carbon, and also by the amount of combined carbon present in the form of pearlite.

Deformation and Fracture of Iron and Mild Steel.—Mr. Rosenhain's report is a continuation of earlier work on "The Plastic Yielding of Iron and Steel," the conclusions of which were not accepted by Heyn, Osmond, and others. Further experimental work has been conducted with a view to clearing up these differences, but unfortunately the abstract simply presents the conclusions reached, giving little or no reference to the actual work done. The author contends that deformation occurs by slip and twinning, and that the material lying between adjacent slip bands undergoes no distortion. In discussing partial plasticity immediately following overstrain in iron and steel, the view is held that the temporary plasticity of the metal is due to the formation of a layer of mobile molecules upon surfaces of slip, recovery of elasticity taking place when the mobile layer is reabsorbed into the crystalline system surrounding it. The microscopic evidence is obtained by rapidly and carefully polishing specimens of overstrained metal, in which recovery has not yet taken place; on suitably etching these traces of slip bands are revealed, but if the same process be applied after recovery is complete no trace of slip bands is found. The author regards this as evidence that the mobile molecules do not permanently retain an "amorphous" condition, as Beilby's original theory would require, unless the deformation has been extremely severe. In the latter case the layers of disturbed molecules would be too thick to be completely reabsorbed in the crystalline system during the brief period of mobility; this consideration accounts for the appearance of traces of slip bands in etched sections close to tensile fractures of ferrite. In connection with this modification of Beilby's theory the author discusses the causes of the hardening of metal by overstrain, and concludes that the phenomena can be explained without recourse to Beilby's hard amorphous layers. These views are supported by a detailed study of the behaviour of alloy *K*, recently described by Carpenter, Hadfield, and Longmuir. The occurrence of the change of constitution which accompanies plastic strain in this alloy is shown to be confined to the surfaces of slip, and is regarded by the author as analogous to the crystallisation which occurs in some supersaturated solutions under the influence of friction. The author contends that if the change in this alloy consisted merely in the formation of an amorphous phase, then on Beilby's theory *all* metals should behave in this way; the fact that the change only occurs in alloys of special composition proves that it arises from the constitution of the alloy and is not merely a more clearly marked example of a universal process. The second portion of the work deals with the modes of fracture of iron and mild steel under various conditions. The conclusions reached are that

in tensile fractures the break runs almost indifferently through ferrite and pearlite, owing to the fact that the previous extension of the metal has weakened and in part even ruptured the pearlite. In shock fractures the pearlite asserts its superior strength, and is avoided by the fracture, while fissures are fo med in the ferrite. The features of bending fractures are found to be of an intermediate character.

The Preparation of Carbon-free Ferro-Manganese.—Messrs. Roberts and Wraight record a large series of experiments on the constitution of ferro-manganese, and of efforts made to deprive the alloy of its carbon. A feature of interest is found in the determination of the melting and critical points of a typical ferro-manganese.

	per cent.		
Manganese ...	82·360		
Iron	10·000	Solidification Point	1230° C.
Silicon	0·563	Critical Points	1130° C.
Sulphur	trace		1000° C.
Phosphorus ...	0·300		915° C.
Arsenic	0·750		
Combined Carbon	6·560		
Graphite	0·120		

Turning to the decarbonising experiments, a large number of cementations in various *media* were carried out, but in no case was the metal sensibly deprived of its carbon. However, in the case of Spiegel, a carbon reduction is possible. Experiments made by blowing air through ferro melted in a basic crucible resulted only in a loss of manganese, the product consisting almost entirely of iron with 3·12 per cent. carbon. Further experiments show that air, carbon dioxide and hydrogen all fail to eliminate carbon from ferro-manganese. Other attempts include melting with various additions such as lime, calcium, magnesia, titanium oxide, but the most promising results have been found in the employment of manganese oxide, the carbon reduction then taking place as follows:—

$$Mn_3C + MnO = 4\,Mn + CO.$$

Melting with the addition of Mn_3O alone gave very satisfactory results, and the following fusions were conduced on the sill of an open hearth furnace in special basis crucibles:

FERRO-MANGANESE MELTED WITH Mn_2O.

	Manganese per cent.	Iron per cent.	Silicon per cent.	Carbon per cent.
Original metal	80·6	11·9	0·40	6·72
Melted for—				
90 minutes...	63·2	29·8	0·38	3·50
60 ,, ...	74·6	20·0	0·33	4·72
180 ,, ...	73·7	22·7	0·36	2·79

This evidence shows that the refining of commercial ferro-manganese is possible, and considering the length of fusion, together with the reduction of carbon and the amount of manganese lost, the outlook is decidedly hopeful, for it must be allowed that experiments on a small scale invariably yield results of minimum efficiency.

The Hardness of the Constituents of Iron and Steel.—Mr. H. C. Boynton, by an application of the micro-sclerometer, has determined the hardness of the constituents of iron and steel, and his results are embodied in the following table.

Constituent.	Present in.	Average Hardness.	Ratio.
Ferrite...	Electrolytic iron	460	1
,, ...	,, ,, quenched	990	2·15
,, ...	Average of all unhardened samples ...	610	1·03
,, ...	Commercial wrought iron	686—1,643	1·5—3·6
Pearlite	Series 0·13 to 1·52 per cent. carbon ...	842—4,711	1·8—10·3
,, ...	Series 0·35 to 0·86 per cent. carbon ...	1,745—2,150	3·8—4·2
Sorbite	0·48 and 0·58 per cent. carbon steel ...	2,400—24,650	5·2—53·6
Troostite	Steel 0·58 per cent. carbon...	40,564	88·2
Martensite	Series 0·20—1·52 per cent carbon... ..	17,896—120,330	38·9—261·6
Austenite	White cast iron (3·24 per cent. carbon)...	47,590	103·4
Cementite	,, ,, ,, ,, ,, ,, ,, ...	125,480	272·8

GENERAL METALLURGY.

Recent Researches on Industrial Alloys.—M. Guillet in the *Revue de Métallurgie* reviews recent researches in this direction, and at the outset states that the union of two or more metals may give rise to one or other of the following conditions. (1) The metals separate during cooling as in alloys of zinc and lead. (2) The metals remain mechanically mixed as in the case of copper and chromium, and copper and tungsten. (3) The metals dissolve one in the other, and when cold form solid solutions as in bismuth antimony, silver, gold, &c. (4) One of the metals may present divers allotropic forms as with alloys of iron. (5) Definite combinations may be formed as exemplified in copper-tin alloys by Cu_3Sn and in copper aluminium alloys by Al_2Cu. AlCu, &c. (6) The metals give birth to a combination which is dissolved in one of

the initial metals or a constituent formed by them.

An example is found in SbSn which is soluble in the antimony of the alloy. The author emphasises the importance of solid solutions, and shows that the constitution rather than composition is the determining factor in the mechanical properties. Passing to alloys themselves, the author deals with iron alloys, but the features noted have been already dealt with in these columns. Of the general alloys, a series of tests of copper-nickel alloys are of interest, and the following table summarises the more salient features.

State.	Contents in Copper per cent.	Max. Stress.	Elastic Limit.	Elongation per cent.	Shock. Frémont.	Hardness. Brinell.	Colour.
As drawn	94·91	19·8	16·5	27	22	63	rose
"	90·70	19·1	16·3	14	20	61	pale rose
"	85·66	31·0	30·8	2	7	73	yellowish white
"	80·60	32·3	32·3	2	6	73	very clear white
"	70·15	32·0	30·5	6	3	88	grey white
Annealed at 750°	94·91	16·5	3·3	44	32	53	rose
" "	90·70	16·3	2·7	40	34	53	pale rose
" "	85·66	15·1	2·1	19	10	57	yellowish white
" "	80·60	23·7	19·7	15	8	60	very clear white
" "	73·95	24·4	19·3	9	7	65	grey white
" "	70·27	25·3	22·4	9	4	71	grey white

After reviewing other aspects, the author concludes with a reference to alloys of aluminium-manganese, stating that when low in the latter metal these alloys possess an industrial interest. Further, they resist the action of water and sea water better than any of the other alloys of aluminium. The following table gives the mechanical properties of a few of these low manganese alloys.

Composition.		Mechanical Properties.	
Aluminium.	Manganese.	Maximum stress.	Elongation per cent.
99·92	0	10·2	7
99·51	0·42	11·5	6
98·03	0·84	13·2	6
97·21	1·65	14·6	6
97·07	2·73	15·3	5

Unsolved Problems in Metallurgy.* —Mr. R. A. Hadfield's treatment of the problems awaiting solution should give a keen incentive to research. But before taking up research the advice offered by one, who has done so much towards extending the bounds of knowledge, should be carefully studied. We therefore quote the following, not only in the sense of good advice from a well-known authority, but also as possessing a direct bearing on present day tendencies in metallurgical researches which are not always undertaken with an "open mind."

"It is an essential condition of success in research that the investigator should possess two apparently opposite qualities. He should be free from bias in favour of old views and open-minded for the reception of new ones. No prejudiced person can be a good investigator, for prejudice misleads the senses when observing results, and hampers the judgment when interpreting phenomena. Original research needs independent thought. Science ignores mere authority, and requires in its stead reasonable evidence; it demands also the sacrifice of personal pride, and that its study should be approached with true humility."

* The Institution of Civil Engineers, "James Forrest" lecture.

FOUNDRY PRACTICE.

Open Hearth Steel Castings.—In continuation of his series Mr. W. M. Carr deals in the April issue of the *Foundry* with manipulation in acid practice. The reactions of typical heats are studied in detail, and in conclusion a series of "principal points" are given, and are well worth recapitulating. These points are as follows:—

(1) To charge enough pig iron so that the charge will carry a sufficiently high initial carbon to ensure an easily maintained fluidity of bath. A low percentage of pig iron will mean a rapid heat, but at the sacrifice of quality and a very high flame temperature. The less carbon charged the greater the chances of over-oxidation.

(2.) Charge as heavy sections of scrap as possible, and protect it as far as practicable with a covering of pig iron.

(3) Watch the flame to guard against undue burning of stock. This point calls for a high degree of skill to maintain the flame conditions, and yet reach the thermal ranges necessary for melting.

(4) Be judicious in adding ore, too much is harmful.

(5) Aim for uniformity of product in a given class of work.

(6) Over-anxiety for tonnage will make the scrap pile grow.

In the May issue of the *Foundry*, Mr. Carr takes up basic practice, and likens the process to a laboratory experiment on a large scale. Careful intelligent work combined with practical experience makes it possible to put basic practice on the same plane of efficiency as acid melting, notwithstanding prejudice to the contrary existing in some minds. After describing the method of charging and the routine of the process, the author examines some of the general aspects, stating that it is not possible to melt a mass of pig iron and steel scrap without the formation of oxides and their subsequent solution in the bath so long as it remains uncovered by a protective layer of slag. Good practice demands a dividing line between speed and slowness, between a sharp flame and a soft one, and these features are difficult to attain. The quantitative expression of dissolved oxides cannot be stated, but their influence can be detected in varying degree. This evil of over-oxidation is traced to the flame action, and the non-success and prejudice against basic steel is largely due to this cause. In expressing the difference between basic and acid steel castings with regard to physical properties, it is stated that basic steel is more likely to contain dissolved oxides than acid when both steels are produced under comparative conditions as to attention during the steel-making process.

Moulding Sands.—M. Vinsonneau, in the *Revue de Métallurgie*, examines in general terms the question of moulding sands and their use in the foundry. Chemically moulding sands consist of silica, alumina, oxide of iron, chalk, and occasionally alkaline salts or other foreign bodies. Alumina gives the bond, and may vary in amount according to the character of the moulds. Generally, new sand for brass-moulding ought to contain 10 per cent. alumina, 8 per cent. for cast iron, and 5 to 7 per cent. for steel. Irrespective of composition all sands ought to be refractory, porous, and capable of taking and retaining impressions from a pattern. As a test of the latter, the author suggests squeezing a ball of sand in the hand, after which the ball should distinctly retain the lines of the skin. An excellent diagram with the properties of sands graphically plotted accompanies the paper.

Specifications for Foundry Pig Irons*.—Mr. W. B. Parker, in a paper before the Birmingham section of the British Foundrymen's Association, clearly shows the advantages which would accrue by the adoption of a system of specifications for foundry irons. Any system must naturally consider (1) the composition and grading of the chief classes of pig iron already in use, and (2) the compositions and gradings which will be most suitable for the largest number of purposes, or for the largest individual demands. Keeping these points in sight Mr. Parker gives a series of specifications actually in use, and which have been formulated from a consideration of the various types of iron available. The latter are considered in detail, and from many analyses maximum limits of composition are proposed for each type.

Finally, the author considers the probable results if a system of standardisation is adopted, and whilst the advantages lie largely with the foundries, it is also shown that in the end the blast furnaces would not suffer.

* *Foundry Trade Journal*. June, 1906.

RECENT BOOKS.

Zinn, Gips, und Stahl vom physikalisch-chemischen Standpunkt. By Dr. J. H. VAN'T HOFF, pp. 35 + 2 plates. (Berlin und München: R. Oldenbourg.) Price, 2 marks.

This memoir embodies a lecture given before the German Society of Engineers, and its distinguished author treats his subject with admirable clearness, but essentially from one point of view. As indicated in the title, this point of view is a physico-chemical one, and the three substances, tin, gypsum, and steel, are found to offer certain analogies with each other. As far as metallurgy is concerned, reasoning by analogy is not a safe guide, and whilst apparently concordant laboratory results may be obtained, these results do not admit of practical application. Therefore, whilst the matter presented has no practical value, it has a high theoretical interest, and on this account is worth careful study. Naturally practice should agree with theory. Unfortunately this happy state has not yet been attained in at any rate some sections of modern metallurgy.

Higher Mathematics for Students of Chemistry and Physics. By J. W. MELLOR, D.Sc., pp. xxi. + 631. Second edition (enlarged) (London: Longmans, Green & Co.) Price, 15s. net.

Dr. Mellor is thoroughly at home with his subject, not only so, he has the comparatively rare gift of making his matter attractive. Mathematical treatises are as a rule painful, but this work is the proverbial exception. This is due to the fact that the treatment throughout is sympathetic, mere demonstration is avoided, and the chemical student is started on a road the gradients of which are easily mounted by reference to the things which appeal to him most. For instance, the meaning of the differential coefficient and of a limiting ratio is first explained in terms of the velocity of a chemical reaction, the differentiation of exponential functions leads to compound interest, and hence to the "Compound Interest Law" in Nature. The general equations of straight lines are deduced from solubility curves, discontinuous functions lead to a discussion of Mendeléeff's work on the existence of hydrates in solutions; Wilhelmy's law of mass action prepares for a detailed study of processes of integration, whilst Harcourt and Esson's work introduces the study of simultaneous differential equations.

Every chemical student will find "short cuts" to many of his mathematical troubles. Those who have left student days behind and are engaged in either routine or research will find the book of equal value. Finally, in view of the present trend of physical chemistry, no worker in the field can afford to neglect the valuable assistance offered by Dr. Mellor.

The Founders of Geology. By Sir ARCHIBALD GEIKIE, F.R.S., pp. xi. + 486. Second Edition. (London: MacMillan & Co.)

As a geological writer Sir Archibald Geikie stands unrivalled, and the products of his pen always show a mastery of style equal to the reliability of the matter presented. The present work is no exception, and a most adequate survey of the history of geological science is presented with a literary charm which holds the reader until the last page is reached. On completing the book a feeling of satisfaction remains, and one closes it with considerable respect and admiration for the author.

The growth of geological science is pictured in the careers of some of the chief pioneers, careers which not only include interesting personal details, but also show sympathetic appreciation of the difficulties encountered, and admirably reflect the scientific spirit of the periods depicted. The first chapter gives a clear sketch of geological ideas prevalent among the Greeks and Romans, and concludes with:—

"The fate of the Roman Empire and the inroads of the barbarians arrested for centuries the progress of natural history investigation. When this progress was resumed, towards the end of the middle ages, a new spirit of intolerance had arisen from which Antiquity had 'been free,'" p. 41.

Turning to the foundation of volcanic geology, and the resulting controversies:—

"We learn from it (controversy over the origin of basalt) how the advance of truth may be impeded by personal authority; how under guise of the most vigorous induction from fact, the most perverse theories may be supported; how, under the influence of theoretical preconceptions, the obvious meaning and relations of phenomena may be lost sight of, and how even in the realm of science, dry questions of interpretation may become the source of cruel misrepresentation and personal animosity," p. 141.

The two quotations show in telling manner the enormous obstacles confronting the early pioneers, on the one hand theological "intolerance" and on the other "personal authority." The surmounting of these obstacles and the gradual dawn of truth forms a practically continuous narrative full of interesting detail and enriched by many conclusions which have a far wider application than a merely geological one. We should like to reproduce many of these conclusions, but owing to their abundance the difficulty of selection is great and our space is not inexhaustible. In successive stages the narrative leads up to the geological surveys of Great Britain and America, and incidentally a tribute is paid to the work of American pioneers which led to the United States Geological Survey. The concluding

chapter is devoted to a study of the rise of petrographical geology and is associated with the names of William Nicol and Henry Clifton Sorby.

"I have always felt a peculiar satisfaction in the reflection that, though the work of William Nicol was never adequately recognised in his lifetime, nor for many years afterwards, it was his thin slices prepared by his own hands, that eventually started Mr. Sorby on his successful and distinguished career, and thus opened out a new and vast field for petrographical investigation," p. 465.

Practically the book concludes with Sorby's development of petrography and his followers, Zirkel, Rosenbusch, Fourqué and Lévy. Whilst Sorby's work was comparatively long in meeting with recognition, this work compelled the adoption of the microscope by the geologist. Not only so, but his work on opaque substances led to the foundation of metallography. Sorby's work on the structure of metals, comparable in many respects with the structures of igneous rocks, is possibly one of his greatest achievements, at any rate we venture to think that some reference to it might have been included with advantage.

In concluding his work the author emphasises several leading facts, and the following are worth special note. Geology owes its foundation to no select or privileged class. The history of geological science presents some conspicuous examples of the length of time that may elapse before a fecund idea comes to germinate and bear fruit.

"The seeds may be long in showing signs of life, but these signs come at last." p. 471.

Finally, in touching on the necessity of not only keeping abreast with modern progress, but also in becoming familiar with past work, the author gives the following advice, which is of a pre-eminently golden character.

"If geologists, and especially young geologists could only be brought to realise that the addition of another paper to the swollen flood of our scientific literature involves a serious responsibility; that no man should publish what is not of real consequence, and that his statements when published should be as clear and condensed as he can make them, what a blessed change would come over the faces of their readers, and how greatly would they conduce to the real advance of the science which they wish to serve." (p. 472).

The Principles and Practice of Iron and Steel Manufacture. By WALTER MACFARLANE, F.I.C., pp. xi. + 265. (London: Longmans, Green & Co.) Price, 3*s.* 6*d.* net.

Mr. Macfarlane states in his preface an intention, so far as the scope of the work permits, to provide sound instruction and reliable information for technical students, metallurgists and engineers. A perusal of the work leads to the conclusion that the ground covered is very familiar to the average metallurgist and engineer, the book must therefore be regarded from a young student's point of view. In such a work the matter presented must be easy of digestion, and the facts, however few in number, must be accurate. As the author has had fourteen years on the "technical staff of iron and steel works," we naturally expect that the latter essential will be realised in the practical side of his subject.

The introductory chapter opens in a somewhat florid style, "stately steamships;" "the powerful locomotive careering along the iron way;" "the pen, the sword, the ploughshare" "hammer, anvil and shot," and phrases of a kindred nature are given as illustrating the applicability of the "useful metal iron." The "stupendous structures of steel and iron" have filled the author with amazement, and in the introduction, at any rate, this stupendity has resulted in incoherency.

The book should really commence with the second chapter in which definitions and preliminary chemical considerations are given. This is followed by a description of the puddling process, which calls for no special comment save that the author would have been well advised to either omit photographs (Figs. 1 and 6 to 9), or to have made an effort to obtain better negatives. In fact the majority of the photographs given would admit of a very considerable improvement, both in point of quality and selection. One can hardly realise why it should be necessary to illustrate the act of shovelling lime into a basic furnace (Fig. 54, p. 130). Fig. 34, p. 89, is intended to illustrate charging lime into a converter, an intention by no means realised in the pictoral effect given. Fig. 52, p. 121, is an empty steel ladle, the educational value of which is extremely hard to realise. Fig. 19, p. 42, is given as a drawing of a steel melting crucible, but it hardly resembles the familiar "pots" of practice, the lids of which are not usually provided with a knob as shown by the author.

The treatment of the crucible steel section is largely founded on Seebohm's paper of twenty-two years ago, and the matter is not improved by editing. In describing charging the pots, the essential operation of sanding is omitted. The charges are described as containing some fluxing material and some physic. Further information would be obtainable if the author condescended to details of these fluxing materials and the description of "physics" as compounds containing manganese is neither good nor yet to the point. Manganese or other additions are made for specific and well-known purposes, and to describe them as physics reduces a definite process down to one of mere quackery. On p. 46 the following remarkable statement occurs:—

"Inferior steel must be teemed into the mould as soon as possible after it has become perfectly fluid and as hot as the pot is likely to stand the strain of pulling out. Higher class steel requires killing, that is, requires to be kept

in the furnace for about half-an-hour after it has become fluid, and it must be poured at a proper temperature."

Experience shows that the way to produce inferior steels is not to kill and to cast as hot as possible. If this plan is followed, some interesting though hardly commercial ingots are obtained. In attempting to elucidate the author's meaning we can only conclude that by inferior steels he implies charges initially high in manganese. To a certain extent such a charge on reaching the fluid state may be partially killed, but we fail entirely to see why inferior steels should be poured as hot as possible, unless it is desired to produce inferior qualities. On p. 49 it is stated that good crucible steel cannot be made from iron containing more than 0·03 per cent. phosphorus, whilst in discussing tool steels it is stated that only 0·02 per cent. phosphorus is permissible.

In point of quality the descriptions of the Bessemer and Siemens processes are similar to that of the production of crucible steel. Thus p. 118:—

"On tapping the furnace the 'metal' comes first, then 'steel and slag,' then mostly 'slag,'" is a sentence which on first reading is most confusing. Then again in discussing the chemical reactions of the "Open Hearth," one gathers ore is not added until the boil is reached, thus p. 122:—

"When this stage (boil) is reached, good, pure, lumpy hematite ore is cautiously fed into the furnace."

Why the ore additions should be delayed until the boil is reached is not stated, and the treatment of this section is not in accord with present or past Open Hearth practice.

The chapter devoted to foundry practice shows unfamiliarity with the usual methods of producing iron and steel castings. A short description of malleable iron castings is given, and from the table of composition, p. 169, we extract the following interesting results:

	Before Melting.	After Melting.	Annealed Castings.
Sulphur per cent. ...	0·03 ...	0·38 ..	0·057

The second result must surely be a misprint, if not, the three results are most remarkable.

One good feature of the book lies in the fact that the author is very careful to explain by the aid of footnotes the meaning of long words, for example:—

p. 12. "Eliminate" this long word is from the Latin, and in plain English means to thrust out of doors."

p. 97. "Combustible gases are gases which can be burned."

p 113. "Frit" from a Latin word signifying "to roast" means in metallurgy to soften by heat so that the particles stick together.

Traité Practique de la Fonderie de Fer. By G. VANDER HAEGHEN and L. LEDENT, pp. 384. Liége. Charles Desoer.

This is a really good work on the more familiar side of iron founding, giving that essential to all technical works, familiarity with the methods described. M. Ledent's original work remains practically untouched, but the book as a whole has been brought up-to-date by M. Vander Haeghen. These additions form the second part of the book, taking the form of comment or amplification of matter embodied in the first portion. In a sense this is confusing, for one has to read the two parts simultaneously. The ground covered starts with the preparation of moulding sand, green sand moulding, methods of sweeping, gear moulding and dry sand moulding. Core making and loam moulding are included, and also a good account of cupola practice. Written from a moulder's point of view the methods given, though in common use, are worth studying, and the student of foundry practice will find the book a reliable guide.

The only bad feature of the book lies in its illustrations, which are scanty in number and poor in quality. In particular Fig. 36, p. 89, illustrating machine-moulding of gear wheels, shows a complete ring of teeth, but the bottom face has not yet been strickled out. However, the book can be safely recommended, but in the event of a fourth edition the matter ought to be rearranged in order to give better sequence and the drawings brought more into keeping with the text.

The Engineering Press.

List of Journals the principal contents of which are regularly indexed. The papers dealt with are those received between the 10th of the month preceding that of publication and the 10th of the previous month.

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L'Echo des Mines et de la Metallurgie, *Paris*... 45 fr. p.a.
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Zeitschrift des Vereines Deutscher Ingenieure, *Berlin*	1 m. 40 pf.

Civil Engineering.

Coast Erosion and Reclamation, III., IV. *Engineer*, *18th May* and *1st June*, 1906.

Recent Tunnel Construction of the Rapid Transit Railroad in Brooklyn. *Engineering Record*, *12th May*, 1906.

Construction of the Gallitzin Tunnel on the Pennsylvania Railroad. *Engineering Record*, *5th May*, 1906.

Difficult Reinforced Concrete Retaining Wall Construction on the Great Northern Railway. *Engineering News*, *3rd May*, 1906.

A "Page" Bascule Bridge at San Francisco. *Californian Engineering News*, *17th May*, 1906.

The New High Level Railway Bridge over the River Tyne. *Railway Gazette*, *25th May*, 1906.

Viaduct over the River Barrow near Waterford. *Engineer*, *25th May* and *1st June*, 1906.

A Graphical Solution of the Knee-braces Problem. By Malverd A. Howe. *Railway Gazette*, *1st June*, 1906.

New Suspension Bridge at New York. *Engineer*, *8th June*, 1906.

Grade Corrections in the Battery Tunnel, New York. *Engineering Record*, *2nd June*, 1906.

New Facts about Eye-Bars. *Transactions of the American Society of Civil Engineers*, *May*, 1906.

A Simple Method for the calculation of the Bending Strength of Curved Pieces. By S. E. Slocum. *Engineering News*, *May*, 1906.

Building.

Underpinning the Marshall Field Building in Chicago. *Engineering Record*, *5th May*, 1906.

Notes on the Fireproofing in San Francisco Buildings after the Fire. *Engineering Record*, *26th May*, 1906.

The Effect of the California Earthquake on Reinforced Concrete. *Engineering Record*, *26th May*, 1906.

The Pennsylvania Railroad Extension to New York and Long Island: Structural Details of Long Island Power Station. *Engineering News*, *31st May*, 1906.

Heating and Ventilating.

Materials and Measurements.

Some Tests bearing on the Design of Tension Members. By Ed. Godfrey. *Engineering News*, *3rd May*, 1906.

A Case of Failure of Iron from "Fatigue." By W. H. Finley. *Engineering News, 3rd May*, 1906.

A New Magnesium Oxy-Chloride Cementing Material. *Engineering News, 17th May*, 1906.

Ferro-Concrete. Paper by Sven Bylander before Society of Engineers. *Iron and Coal Trades Review, 25th May*, 1906.

Boilers, Furnaces and Fuel.

Explosions of Coal, Gas and Air. *Mechanical World, 11th May*, 1906.

Trials of Producer-Gas Plants. *Power, May*, 1906.

Steam Power Generation, XXI. *Practical Engineer, 11th May*, 1906.

Smokeless Combustion. Abstract: Discussion before Society of Chemical Industry. *Engineer, Chicago, 1st May*, 1906.

Briquetting of Brown Coal. *Proceedings Engineers' Society, Western Pennsylvania, May*, 1906.

Electricity and Gas *v.* Smoke. By C. Alfred Smith. *Electrical Review, 25th May*, 1906.

The "Kurzwernhart" Gas-Saving Process. *Iron and Coal Trades Review, 1st June*, 1906.

Engines and Motors.

250 h.-p. "Korting" Gas Engine—latest type. *Engineer, 18th May*, 1906.

Damping the Vibration of Motors. *Engineer, 18th May*, 1906.

Test of a Turbine-Driven "Sirocco" Blower. *Engineering Record, 12th May*, 1906.

Design of Condensing Plant, IX. *Mechanical World*, 11th *May*, 1906.

Design, Construction and Application of Large Gas Engines in Europe, VII. *Power, May*, 1906.

Engine Barring Gear, IV. *Mechanical World, 18th May*, 1906.

Brake Tests of a 500 k.w. "Westinghouse-Parson's" Turbine. *Engineering Record, 19th May*, 1906.

A New Method of Turbine Control. By Lamar Lyndon. *Proceedings American Institute Electrical Engineers, May*, 1906.

Hydraulics and Compressed Air.

A New Method of Measuring Water in Pump Tests. *Power, May*, 1906.

Air Compressors and Blowing Engines. By C. H. Innes. *Practical Engineer, 18th May*, 1906.

Air-Lift Pumping. By Gustav C. H. Friedrich, Paper before Ohio Society of Mechanical, Electrical and Steam Engineers. *Engineer, Chicago, 1st June*, 1906.

Shop Equipment and Practice.

Machining and Grinding Eccentric Spindle Carriers. By R. Nuttall. *Mechanical World, 11th May*, 1906.

List of Cone and Gear Ratios for Variable-Speed Drives. By W. Owen. *American Machinist, 12th May*, 1906.

Roll Grinding. *American Machinist, 19th May* 1906.

Notes on the Design of Hydraulic Machine Tools, I. (*continued*). *Practical Engineer, 15th May*, 1906.

A Method of Procedure in the Design of "Helical" Gears. *Machinery, May*, 1906.

High-Speed Lathes by J. Parkinson & Son, Shipley. *Engineer, 11th May*, 1906.

An Analysis of the Cutting-off Machine. *American Machinist, 26th May*, 1906.

Stay-Bolt Threading and Turning Machine. *American Machinist, 26th May*, 1906.

Machine Shop Work, XII. By Jos. Horner *Mechanical World, 25th May*, 1906.

Rolling Mill Drive Construction. *Mechanical World, 25th May*, 1906.

Machine Tool Design, XIX., XX. Design of Power Gears. By Prof. J. T. Nicholson and Mr. Dempster Smith. *Engineer, 1st* and *8th June*, 1906.

Milling Machine Fixtures. By E. R. Markham. *Mechanical World, 8th June*, 1906.

The Design of Bending Rolls. *American Machinist, 2nd June*, 1906.

Automatic Safety Attachment for Screw-Cutting. By Johnson, Roberts & Co., Engineers, London. *Engineer, 8th June*, 1906.

Miscellaneous Mechanical Subjects.

New 140-ton Floating Crane for the Tyne. *Marine Engineer, 18th May*, 1906.

Concrete Block Machines. *Scientific American. 12th May*, 1906.

Power House Conveniences. *Power, May*, 1906.

Variable Speed Mechanisms, IX. *Machinery, May*, 1906.

The Design of Billet and Bar Passes. *Machinery, May*, 1906.

Sections of Cast Iron Beams. *Machinery, May*, 1906.

Modern Steam Traps (*continued*). *Practical Engineer, 11th, 25th May* and *8th June*, 1906.

Engine Friction and Lubricants. *Mechanical World, 8th June*, 1906.

The Pedersen Three Speed Bicycle Gear. *Engineering, 11th May*, 1906.

Mechanical Engineering Materials; their Properties and Treatment in Construction. By Edward C. R. Marks. IV. Wrought or Finished Iron. *Practical Engineer, 25th May*, 1906.

A Point in the Design of Spring Rings. *Practical Engineer, 8th June*, 1906.

Belt Driving. By W. O. Horsnaill. *Practical Engineer, 1st June*, 1906.

Machine for Preparing Specimens for testing in Compression. *Engineering, 8th June*, 1906.

Railway and Locomotive Engineering.

Development of Valve and Valve Motion, III. By A. Sinclair. *Railway and Locomotive Engineering, May*, 1906.

Draft Gears. *Railway Master Mechanic, May*, 1906.

Victoria Station, L. B. & S. C. *Railway Engineer, 25th May*, 1906.

Comparative Test of large Locomotive Air Pumps. *Railway and Engineering Review*, 26*th May*, 1906.

Pennsylvania Railroad Extension to New York and Long Island. The Passenger Station in New York. *Railway and Engineering Review*, 26*th May*, 1906.

Six-coupled Narrow Gauge Engine; Egyptian Delta Light Railways. *Railway Engineer*, *June*, 1906.

The Great Western Railway's new London Locomotive Depot. Description of the newly-opened Engine Sheds at Old Oak Common. *Railway Gazette*, 1*st June*, 1906.

Compound Express Engines; Bavarian State Railways. *Railway Engineer*, *June*, 1906.

Steel Flat Cars for Specially Heavy Loads. *Engineering News*, 24*th May*, 1906.

Co-ordinate Geometry applied to Problems in Railroad Alignment. *Engineering Record*, 26*th May*, 1906.

Defects in Locomotive and Car Wheel Tyres. *Engineering News*, 24*th May*, 1906.

Rail Joints. By J. F. Conradi, District Engineer, Leicester, Great Central Railway. *Railway Gazette*, 8*th June*, 1906.

Automobilism and Road Traction.

The Clement-Talbot Petrol Cars. I., II., III., IV., *Automotor Journal*, 12*th*, 19*th*, 26*th May*, 2*nd June*, 1906.

The De la Buire Cars. *Autocar*, 19*th May*, 1906.

The Austin Petrol Cars. II., III., IV., V. *Automotor Journal*, 12*th*, 19*th*, 26*th May*, 2*nd June*, 1906.

The Field of the Electric Tramway and Motor Omnibus. Mr. Manville's Reply to the Discussion at the Automobile Club. *Automobile Club Journal*, 17*th May*, 1906.

The "Gearless" Napier Car. *Automotor Journal*, 12*th May*, 1906.

The 30 H.-P. Westinghouse Car. *Autocar*, 26*th May*, 1906.

The 10 H.-P. Adams-Hewitt Light Car. *Autocar*, 26*th May*, 1906.

Multi-cylinder Engines for Motor Cycles. By Bertram Chatterton. *Automobile Club Journal*, 7*th June*, 1906.

The New 45 H.-P. Daimler Car. *Autocar*, 2*nd June*, 1906.

The New G. & A. Carburetter. By MM. Grouvelle and Arquembourg. *Autocar*, 2*nd June*, 1906.

The Rocket-Schneider Cars. *Automotor Journal*, 9*th June*, 1906.

Electric Lighting.

Utilization of Colloids. Metallic Lamp Filaments. By J. Swinburne. "*Times*" *Engineering Supplement*, 16*th May*, 1906.

On the Measurement of Illumination. *Electrician*, 18*th May*, 1906.

The "Vickers-Hall" System of Electric Lighting for Railway Carriages. *Electrical Review*, 1*st June*, 1906.

Rare Earths and Electric Illuminants. By Murray C. Beebe. *Electrical Engineer*, 8*th June*, 1906.

Causes and Prevention of Faults on Direct-Current Networks. By F. Fernie. *Electrician*, 11*th May*, 1906.

Electrical Generation and Transmission.

Steinmetz Arrangement for Compounding Alternating-Current Generators. *Western Electrician*, 5*th May*, 1906.

The Design of Electric Generators. The Use of Comparative Formulæ in the Mechanical Design of Electric Generators. By W. O. Horsnaill. *Engineering*, 11*th May*, 1906.

The Regulation of the Pressure of Discharge of Lighting Batteries. Paper before Institute of Electrical Engineers, 14th May, 1906. *Electrical Engineer*, 18*th May*, 1906.

On a method of Obtaining Continuous Currents from a Magnetic Detector of the Self-restoring Type. Paper before Royal Society. *Electrician*, 18*th May*, 1906.

The Calculation of Polyphase Induction Motor Windings. By F. T. Chapman. *Electrician*, 18*th May*, 1906.

The Theory of Shop Methods of Testing Single and Polyphase Transformers (cone). By J. W. Rogers. *Electrical Engineer*, 11*th May*, 1906.

The Lancashire Electric Power Scheme. *Electrical Review*, 25*th May*, 1906.

Classification of Alternate Current Motors. *Electrician*, 25*th May* and 8*th June*, 1906.

The Greenwich Tramways Generating Station of the L.C.C. *Electrical Review*, 1*st June*, 1906.

Notes on the Running of Alternators in Parallel. *Practical Engineer*, 1*st June*, 1906.

Electric Traction.

Third Annual Convention of the Iowa Street and Inter-urban Railway Association, II. *Street Railway Journal*, 5*th May*, 1906.

High Tension Direct Current Railway between Cologne and Bonn, Germany. *Street Railway Journal*, 5*th May*, 1906.

Power for Electric Railway Traction. By Prof. R. H. Smith. *Times Engineering Supplement*, 9*th May*, 1906.

Thermit Rail Welding in New York City. By R. F. Kilker. *Street Railway Journal*, 12*th May*, 1906.

Freight Handling Practice on Electric Railways. *Railway and Engineering Review*, 12*th May*, 1906.

First London Tramway across the Thames. *Tramway and Railway World*, 10*th May*, 1906.

South Shields Electric Tramways. *Tramway and Railway World*, 10*th May*, 1906.

Single-Phase Railway for the Milan Exhibition, 1906. *Electrician*, 11*th May*, 1906.

The Dundee, Broughty Ferry and District Tramways. *Electrical Review*, 11*th May*, 1906.

Motor and Trailer Trucks for the New York Central Electric Service. *American Engineer and Railroad Journal*, *May*, 1906.

Automatic Signalling on the Underground Railways of London. *Engineering*, 25*th May*, 1906.

New Electric Trains on the Metropolitan Railway. *Electrician, 1st June*, 1906.

Electric Locomotives on the Metropolitan Railway. *Electrician, 1st June*, 1906.

Miscellaneous Electrical Subjects.

Eighty-five h.-p. Electric Winding Engine. *Engineering, 18th May*, 1906.

Rewinding Dynamo Electrical Machinery. Norman G. Meade. *Power, May*, 1906.

Wireless Telegraphy. *Electrical Review, 18th May*, 1906.

Mechanical Design of Commutators for Direct-Current Generators. By A. Livingstone. *Electrician, 18th, 25th May* and *1st June*, 1906.

Electric Cranes, XXII. *Mechanical World, 18th May*, 1906.

The General Supply of Electricity for Power and other Purposes: Its Commercial Character and Controlling Management. By James N. Shoolbred. *Journal Society Arts, 25th May*, 1906.

Electro-magnetic Controlling Gear for Governors. *Engineering, 1st June*, 1906.

Electrically Operated Coke-Drawing Machines. By Frank C. Perkins. *Electrical Engineer, 1st June*, 1906.

Alternating-Current Signal Circuits in the New York Subway. By J. M. Waldron. *Western Electrician, 19th May*, 1906.

Hot Water, Heat and Electric Light from a Central Station. *Engineer, Chicago, 1st June*, 1906.

Flour Bleaching with the Aid of Electricity. *Electrician, 8th June*, 1906.

Mechanical Troubles with Induction Motors. *Engineer, Chicago, 1st June*, 1906.

The Municipal Electrolytic Hypochlorite Plant at Poplar. *Electrical Review, 8th June*, 1906.

Measurement of Temperature by Electrical Means. By Edwin F. Northrup. *Proceedings American Institute Electrical Engineers, May*, 1906.

Marine Engineering and Naval Architecture.

The Turbine-Driven Channel Steamer, *Viper*. *Engineering, 18th May*, 1906.

One Thousand Ton Bagging Lighter. *Marine Engineer, 18th May*, 1906.

The Moulding of Propellers. *International Marine Engineering, May*, 1906.

Contract Trial Performance of the United States Battleship, *Louisiana*. *International Marine Engineering, May*, 1906.

Motor Boats, XI., XII. By Dr. Wm. F. Durand. *International Marine Engineering, May* and *June*, 1906.

Stability Calculations by Planimeter. By R. E. Anderson. *International Marine Engineering, May*, 1906.

The Buoying and Lighting of Navigable Channels. By Brysson Cunningham, *Engineering, 11th May*, 1906.

The Japanese Battleship, *Katori*. *Engineering, 11th May*, 1906.

Propellers, IV., V. By A. E. Seaton. *Marine Engineer, 25th May* and *8th June*, 1906.

Multiple Propellers: Some possible Causes of Vibration and Loss of Efficiency. By C. H. Wingfield. *Marine Engineer, 25th May*, 1906.

Progress of the Marine Steam Turbine. *Engineering, 25th May*, 1906.

The New Cunarders. By Sir Wm. White, K.C.B. "*Times*" *Engineering Supplement, 6th June*, 1906.

French *Dreadnought*. *Engineer, 1st June*, 1906.

The Holland-America Liner, *Niew Amsterdam*. *International Marine Engineering, June*, 1906.

Lengthening of the Steamer *Hamilton*. By Alex. Wills. *International Marine Engineering. June*, 1906.

The New French Liner, *La Provence*. *International Marine Engineering. June*, 1906.

Steam Trials of H.M. Battleship *Africa*. *Engineering, 8th June*, 1906.

Power-Door Mechanism. *Marine Engineer, 8th June*, 1906.

Water Supply.

Sewage.

Streets and Pavements,

Engineering Economics and Works Management.

A Comprehensive Time Card. *American Machinist, 12th May*, 1906.

The Commercial Organisation of Engineering Factories, V., VI., VII., VIII. *Engineer, 11th, 18th, 25th May*, and *1st June*, 1906.

Piecework. *American Machinist, 19th May*, 1906.

The Need for Systematic Methods in the Conduct of Engineering Works. By W. O. Horsnaill. *Electrical Review, 8th June*, 1906.

Miscellaneous.

The Recent Earthquake in Central California and the Resulting Fire in San Francisco. *Engineering News, 10th May*, 1906.

Comments of Californian Engineers on the Earthquake and Fire. *Engineering Record, 5th* and *12th May*, 1206.

Some Effects of the San Francisco Earthquake on Waterworks, Streets, Sewers, Car Tracks, and Buildings. *Engineering News, 17th May*, 1906.

Street Traffic in New York City, 1885 and 1904. By Clifford Richardson. *Proceedings of the American Society of Civil Engineers, May*, 1906.

The Economic Production and Uses of Distilled Water. By H. Leffmann. *Proceedings of the Engineers' Club, Philadelphia, April*, 1906.

The Municipal Asphalt Repair Plant at Pittsburg, Pa. *Engineering News, 31st May*, 1906.

An Improved Pneumatic Tube System. *Engineering Record, 2nd June*, 1906.

The Structural, Municipal, and Sanitary Aspects of the Central Californian Catastrophe, I.: A Statement of Conditions produced by Earthquake and Fire, and Conclusions drawn from them. By C. G. Hyde. *Engineering Record, 2nd June*, 1906.

NOTICES.

Locomotive Testers. The North-Western Railway of India have had manufactured to their order by Messrs. W. and T. Avery, Ltd., of the Soho Foundry, Birmingham, one of their Locomotive Testers with twelve tables, each with a capacity of ten tons, each table 4 ft. 8 in. by 12 in. with 5 ft. 6 in. gauge. This firm have also recently supplied fifty-four of their well-known Portable Locomotive Testers for the East Indian Railway, the Southern Mahratta Railway, and the Eastern Bengal Railway.

Mechanical Transport Equipment for the Portuguese Government. In refutation of the statement so frequently heard that manufacturing and commercial enterprise are declining in this country, it is pleasing to relate that the Portuguese Government, requiring steam motor wagons and ambulances, placed the order in this country, although it was competed for by many Continental firms; the vehicles in question being originally intended for use in a punitive expedition organised by the Portuguese for their possessions in West Africa. The remarkable celerity with which the work was carried out (thirty-nine days) reflects much credit on the contractors and all the British labour concerned. The mechanical transport equipment supplied by Messrs. John I. Thornycroft & Co., Ltd., Chiswick, consists of four 5-ton steam wagons with eight 3-ton trailers and a 30-cwt. steam van specially fitted up for the use of staff officers. The 5-ton wagons have lorry platform bodies, and are of the well-known "Thornycroft" Colonial type, with vertical central-fired water-tube boilers, adapted to burn wood, if desired, and compound 45-h.p. engine. The wagons are of specially strong construction, to enable them to be used satisfactorily in rough country, and the transmission gear is all enclosed. Two of the wagons have interchangeable ambulance bodies, built by Messrs. Carter, of London, for Messrs. Thornycroft. These bodies carry twelve men each, there being eight stretcher beds in each ambulance, and are the largest ever built. Owing to the rough country to be traversed, patent automatic weight-adjusting, spring-supporting gear for the stretchers was invented and fitted by Messrs. Carter. This invention will enable the motor ambulance to be very largely used in the near future, and it is, therefore, of great interest. The special light steam van is comfortably fitted up for use by day or night. The wheels are fitted with solid rubber tyres and the wagon is capable of a speed of about fifteen miles an hour on the level. The boiler is of the "Thornycroft" vertical water-tube type, and the engine is a compound developing about 25-h.p. The transmission is by "Hans Renold" chain to differential on back axle. All the wagons have satisfactorily passed very severe tests in Lisbon, and are giving the Portuguese authorities great satisfaction.

Ferry Steamers for Calcutta Port Commissioners. Messrs. John I. Thornycroft & Co. Ltd., Woolston Works, Southampton, have just concluded a contract with the Indian Government for the Commissioners of the Port of Calcutta for seven twin screw ferry steamers for service on the Hooghly, through their London representative, Mr. J. H. Apjohn.

They will be 100 ft. long between perpendiculars, 20 ft. in beam, and 10 ft. moulded depth, and will have a maximum draft of 5 ft. fully loaded, the guaranteed speed being 12 knots.

The vessels are arranged to carry, in all, about 200 passengers, seating accommodation has been arranged for 100 of these. The passenger space is divided into two classes, the first class being situated forward on the upper deck in front of the boiler casing, and separated by portable barriers from the remainder of the space which is set apart for second class passengers.

On the upper deck there are three wide gangways on either side, giving ample room for embarking large numbers of passengers quickly. One of these gangways is arranged for first class passengers and the other two for the second class. The upper deck has a fine area, and will be capable of accommodating a large number of passengers with comfort. A light wood awning covers this deck.

Access to cabins is gained by three open companions, two are situated forward, one being for access to first class lavatory and the other for access to second class cabins. Seats are arranged all round the forward and after cabins, thus affording ample seating accommodation.

The machinery will consist of two sets of vertical tri-compound condensing engines supplied with steam from one cylindrical boiler working under forced draught on the closed stokehold principle.

The Mirrlees Watson Co. have recently secured a number of important contracts for independent condensing plant including the following: *City of Leeds Electric Lighting Station*:—Surface condensing plant to work in connection with a 3,000 k.w. Willans turbine. The condenser is of the vertical open top type. It is especially designed to meet such trying conditions as is met in using condensing water from the river Aire, which contains a large amount of woolly material floating down from the mills, and which in an ordinary way chokes the condenser tubes. The condenser can be easily cleaned whilst the plant is in operation, and the flow of water can be reversed as desired to facilitate the cleaning. In this special case the water has only a single course of flow through the condenser. A vacuum of 28 in. is to be maintained under ordinary working conditions. The circulating water is delivered by a motor-driven centrifugal pump, and the air pump is of the Mirrlees Edwards' type, 3-throw, 22 in. dia. x 15 in. stroke, driven by a 3-phase motor.

For the Dalzell Steel Works, Motherwell (Messrs. David Colville & Sons, Ltd.):—An elevated self-draining counter-current jet condensing plant, dealing with 80,000 lbs. steam per hour. This steam is taken direct from several large rolling mill engines and the plant is specially designed to meet the intermittent discharge from such engines. The condenser is erected on steel tower and is self-draining through barometric pipe. The air is dealt with by a Mirrlees dry slide valve air pump, and the condensing water is delivered to condenser and cooling tower by motor driven centrifugal pumps.

Motor Driven Lifeboats. The Royal National Lifeboat Institution, who are always ready to experiment with any invention which may improve the efficiency of their boats, have recently directed

their attention to the problem of adopting the internal combustion engine in their lifeboats. This type of engine possesses considerable advantages over the steam engine for this class of work, the most important of which are the smaller space for the same horse-power, the ability to start up at once without any delay to raise steam, and the fact that the motor can be so placed amidships as to admit of the use of oars without any inconvenience.

The latest experiment in this direction has been made by the installation of a Thornycroft 4-cylinder 24 h.-p. motor in the Newhaven Lifeboat *Michael Henry* with most satisfactory results.

The motor is auxiliary to, and not in place of, the oars usually used, but the boat as now equipped is far more handy than the usual type of lifeboat.

The trials were carried out on the Thames under the supervision of Capt. Nepean, the chief inspector of lifeboats, and in the presence of several members of the National Lifeboat Institution, and the average speed attained with the motor only and with all equipment on board and ballast to the weight of a full crew was 7·3 knots.

In addition to the speed trials very strict capsizing trials were insisted on and fulfilled to the complete satisfaction of the National Lifeboat Institution authorities.

These trials were to determine whether the engine casing was perfectly water-tight, and whether the motor would, as required, stop automatically when the boat was keel uppermost.

If the propeller continued to revolve when the lifeboat was capsized, it would be liable to injure anyone coming in contact with it and foul ropes, &c.

The boat was completely capsized twice, the motor having previously been started in each case, and each time it stopped automatically when the boat was in an inclined position.

The engine casing proved to be absolutely water-tight, which shows good workmanship and design, as all control rods, pipes, &c., have to pass through water-tight glands.

The motor started very easily, and ran very satisfactorily after the capsizing of the boat.

The result of these trials reflects great credit on the makers of the motor, Messrs. John I. Thornycroft & Co., Ltd., of Chiswick, who designed a special arrangement to automatically switch off the ignition and cut off the supply of petrol when the boat began to heel over.

Messrs. W. & T. Avery, Ltd., of the Soho Foundry, Birmingham, notify us that the North-Eastern Railway Co. have placed an order with them for two 30-ton chain testing machines. This firm has also secured an order from the Mersey Dock and Harbour Board for two 30-ton improved railway weighbridges, made sufficiently strong to allow of a 60-ton locomotive passing over.

Improvements in Bucket Dredgers. A specification (No. 18,093; 1905) has recently been completed by Mr. J. Andrews, "Holmsley," Old Charlton, S.E., proposing a method of constructing bucket dredgers, in which several important improvements appear to be embodied. These are as follows:—1. Considerable reduction in the height of top tumblers, as applied to existing dredgers. 2. Buckets to discharge directly into the shoots, obviating the loss of dredger material. 3. Reduction in top weight, giving stability to dredgers for sea-going. 4. Economy in cost of working. 5. Snug and compact arrangement of dredging gear and vessel. 6. Reduction of strain on the tumbler shafts.

"Kramos," Ltd., Bath, have opened a head sales office at 169 and 170, Shoreditch High Street, London, E.C. (Cable address: Edwastone, London), where all communications should be addressed.

Standard Templates for Pipe Flanges. The Engineering Standards Committee have not only drawn up various lists of standards, but have, with a view of ensuring greater accuracy and interchangeability, introduced series of standard templates for tramway, bull-headed and flat-bottomed rails, and for pipe flanges.

It was felt that templates for pipe flanges could be manufactured more cheaply and accurately in quantities by proper machinery than by the old-fashioned way of making a single template at a time. The committee therefore entered into an arrangement with Messrs. Joseph Sankey & Sons, Ltd., of Bilston, who have long been known in the electrical world for their accurate stamping of core discs for dynamo and motor construction, to manufacture commercial sets of standard pipe flange templates in large quantities.

In order to ensure a high degree of accuracy in the commercial sets of templates, the committee in the first instance arranged for the manufacture of a set of male templates for all the sizes and drillings recommended by them in their standard tables for pipe flanges (Report No. 10). These male templates, which were made with extreme care, were forwarded to the National Physical Laboratory, where they were carefully measured up and a certificate of their accuracy obtained. All the commercial sets are carefully checked against the verified standard set before being issued. Accuracy of drilling is thus ensured, and it is hoped that the difficulty of flanges made by one maker refusing to fit the flanges of another, though they both may purport to be drilled in accordance with the committee's recommendations, will be overcome. All engineers at one time or another have experienced the difficulty and annoyance of finding that flanges which have been nominally drilled to the same dimension, refuse to go together because either the bolt circles are slightly different or the spacing of the holes is not quite uniform. The fact that all commercial templates will fit in any position the corresponding certified male templates, effectually does away with these difficulties, and the templates being made in large numbers, Messrs. Sankey are enabled to offer them at a price below that at which an engineer could make them for himself.

The templates are made of thin steel plate, painted over with aluminium paint, a small piece being cut out at the extremity of each centre line so as to enable the fitter to see that the centre line of the template coincides with the centre line of his flange.

Messrs. Meldrum Bros., Ltd., of Timperley, near Manchester, have just secured an order for the equipment of three destructor stations, each having a normal capacity of 100 tons per day of twenty-four hours. Each station will be fitted with three of their regenerative furnaces, with large boilers of the "Babcock and Wilcox" type. The aggregate normal capacity of these plants is over 500 tons per diem, and together form one of the largest destructor contracts ever placed. They are

to be erected on different sites in the city of Paris. Messrs. Meldrum Bros., Ltd., have also secured an order from the municipality of Pretoria, South Africa, comprising one 4-grate unit with large boiler, containing buildings, &c.

Correspondence is invited by the sole concessionaires under the British Patent Rights for Great Britain, Ireland, and the Isle of Man, of "Eternit" Asbestos Roof Slates and Insulating Sheets, with building supply firms desiring agencies in the principal centres throughout Great Britain. Apply Manager, ENGINEERING REVIEW.

Double Cast-Iron Bar Testing Machine. Reference was made in the June issue to this machine, which is made by Messrs. Samuel Denison & Son, Ltd., Leeds. We omitted to mention that, in addition to transverse tests, the machine is capable of being used for tensile tests, it being necessary to move only one pin in order to effect the change. The capacity for transverse tests is two tons, and for tensile tests four tons.

Obituary. We regret to have to announce the death of Mr. Jeremiah Eugene Mathewson, managing director of Messrs. Geo. Richards & Co., Ltd., Broadheath, which occurred on May 31st at his residence, "Fray Bentos," Manchester Road, Altrincham.

Cold Iron Saw and Sharpener. Particulars are to hand of a series of machines of this type made by Messrs. Carter and Wright, Halifax, the smallest cutting sections of 2 in. by 4 in., the largest 4 in. by 16 in. The saw blade is flush side, and is fastened by countersunk head bolts and nuts to the spindle, on which is a phosphor bronze worm wheel driven by steel worm and bevel wheels from the driving pulleys. The feed is by a 3-speed cone on the main driving shaft, which drives a 3-speed cone on the shaft in front of the machine, on which is a worm which drives the worm wheel connected to the saddle feed screw. A trip motion is provided for disengaging the feed at any predetermined point.

The bed forms a trough for the lubricant, and is carried on a box leg. The table for fixing the work has planed T slots, and is provided with a holding-down plate and bolts.

A self-acting saw sharpener is fixed at the back of the machine. The emery wheel travels across the saw, thus making a proper shape of tooth perfectly cylindrical and at right angles to the axis of the saws. This is a very important feature in cold sawing, as it prevents the liability of the saw running out of line, jamming and breaking, which often occurs because the saw is keener on one edge than the other. The emery wheel can be set to the greatest nicety and locked in position. Spare saws can thus be sharpened whilst the machine is at work.

CATALOGUES.

Mather & Platt, Ltd., Salford Iron Works, Manchester. Revised booklet on Electric Train Lighting, including a description of Dr. Rosenberg's Patent Train Lighting Dynamo for which this Company own the patents in the United Kingdom and Colonies.

The dynamo, which constitutes the essential feature of this system of train lighting, is of the simplest construction, and no matter how the speed may vary above a certain predetermined limit, its voltage remains to all intents and purposes perfectly constant.

The dynamo regulates automatically without the use of any external regulating devices; the sense of its voltage is constant and independent of the direction of rotation of the armature, thus dispensing with the necessity for any form of pole-changer. No compound windings for demagnetising purposes, nor shunt resistances with sliding contacts, are required. The belt tension is normal, and the slip therefore only such as is usual with any belt-driven machine. The dynamo may consequently be suspended directly from the coach bogie, thus avoiding distortion and fraying of the belt when negotiating curves, and thereby prolonging its life. One battery only is required, resulting in a more highly-efficient system, saving weight and strain on the coach frames, and diminishing the initial cost of equipment.

Zimmer Conveyor Co., 82, Mark Lane, E.C. New edition of catalogue of the Zimmer Conveyor. This apparatus consists of a light trough supported on inclined laminated spring legs. The trough is set into a springing motion by the driving gear. The material, which is deposited into one end of the trough, travels in a floating stream to the other end.

Aston Motor Accessories, Co., Ltd., Birmingham.—1906 list of "Amac" Specialities, such as radiators, pumps, plugs, terminal clips, contact makers, &c.

G. D. Peters & Co., Moorfield, E.C.—Booklet descriptive of the "Leitner-Lucas" System of Train Lighting.

Cochran & Co., Ltd., Annan.—A calculating card by which the size of any vertical boiler can be read at a glance, according to the indicated or brake h.-p. required, for any range up to 300 i.h.-p., and with various degrees of efficiency, varying from 20 to 60 lb. per i.h.-p. per hour. It is, further, possible to read the size of boilers recommended for different sizes of winches on board ships.

Gent & Co., Ltd., Leicester.—Pamphlet descriptive of the "Nugent" Inch by Inch Water Level Indicator, suitable for small waterworks, wells, tanks and reservoirs, in hotels, public buildings and country houses.

Heenan and Froude, Ltd., Worcester.—Three illustrated pamphlets dealing with Coal Screening and Washing Plants, Railway Rolling Stock and Steel Plate Fans.

W. J. Furse & Co., Nottingham.—Leaflet dealing with a new patent "W" type Switch; Gas and Water Tight Switches, Enclosed Fuses and Switchboards. Also section I. catalogue of Lifting and Haulage Machinery.

Howard Asphalt Troughing Co., Ltd., Trafford Park, Manchester. — Descriptive illustrated catalogue of the "Howard" Asphalt Solid System. The cables are laid in asphalt troughs, and first, hot bitumen and then hot asphaltic concrete is poured over them, welding the whole into a solid mass.